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A Final Certificate That Was Not Final.

When an engineer or architect gives a final certificate to a contractor, the latter is accustomed to believe that his troubles are over, provided the owner is solvent. Nevertheless contracts can be so drawn that the final certificate is of but trifling importance, a fact which is not often the subject of judicial determination, although two or three such cases have been passed upon by courts of final jurisdiction. One of these rather rare cases was recently carried to the Court of Appeals of the District of Columbia by the Mercantile Trust Co., which was on the bond of a contractor who undertook to build twenty-one brick houses in Washington "agreeably to the drawings and specifications made by Melville D. Hensey, architect, and which plans and specifications are signed by the said parties hereto and hereunto annexed, within the time aforesaid, in a good, workmanlike and substantial manner, to the satisfaction and under the direction of Bates Warren, or the architect placed in charge by him, to be testified by writing or certificate under the hand of Bates Warren, or the architect placed in charge by him, and also shall and will provide and find such good, proper and sufficient material of all kinds whatsoever as shall be proper and sufficient for the completing and finishing of all of said twenty-one houses and other works of the said buildings mentioned in the said specifications." The owner agreed to pay the contractor "as the work progresses in the manner and at the time set out in the schedule of payments hereto annexed and signed by the parties hereto and made a part of this agreement; provided that in each of the said cases a certificate shall be obtained from and signed by the architect in charge that the contractor is entitled to payment, said certificate, however, in no way lessening the total and final responsibility of the contractor; neither shall it exempt the contractor from liability to replace work if it be afterwards discovered to have been ill done or not according to the drawings and specifications, either in execution or material; and, further, that the party of the second part shall furnish, if required, satisfactory evidence that no lien does or can exist upon the work."

Although this contract was signed in January, 1900, and under it the houses were to be completed in seven months, yet for some reason Bates Warren, the person named in the contract, did not appoint an architect until April, 1901, when he appointed W. J. Palmer. Before this the original contractor had abandoned the work, which was carried out by the bonding company, with such superintendence as Mr. Palmer gave it after his appointment. In July, 1901, he sent Mr. Warren the following certificate: "The work has been done according to my interpretation of the plans and specifications and where deviations have been made from the plans and specifications it has been where the same have been inconsistent and ambiguous, and in all cases of inconsistency and ambiguity the work has been done according to the interpretation most beneficial to the houses." In accordance with this certificate, the final payment was demanded. The last payment, according to the contract, was to be made "when the houses are fully completed in accordance with the said agreement and the plans and specifications prepared therefor." The owner demanded damages on account of the long delay in the completion of the buildings and because of the manner in which they were constructed, claiming that each house was worth from $2,000 to $3,000 less than it would have been had it been completed according to the agreement.

During the trial of the case there was more than the usual amount of legal complication, which it is uninteresting to follow. The instructive part of the final decision relates to the claim that the architect's certificate of July, 1901, was conclusive between the two parties. The court decides that this certificate was not conclusive, because the terms of the contract do not include any provision that the architect's certificate shall be final between the parties, but merely that the builder must obtain such a certificate before he can claim payment at all. The court rules, in practically so many words, that a contract which provides for the work on a building to be performed in the best manner and with materials of the best quality, subject to acceptance or rejection by an architect, all to be done in strict accordance with plans and specifications, does not make the acceptance by the architect final and conclusive, and will not bind the owner or relieve the contractor from the agreement to perform according to plans and specifications. In this particular case there was a further positive agreement by the contractor to execute and complete all the work mentioned in the specifications in the best and most workman-like manner, and he agreed that final payment was to be made only when the houses were completed in accordance with the plans and specifications. The court then makes the important statement that to make an engineer's or architect's certificate conclusive requires plain language to that effect in the contract, for it is not to be implied. The only case in which the certificate of the architect or his decisions is final without such written agreement is in case of doubt as to the meaning of drawings, in which case reference of such disputed details is naturally made to him.

This decision is unusually interesting, because it is the opinion of a court of final jurisdiction on a subject equally important to the engineer, architect and contractor. It has been repeatedly held by the higher courts in many States that where a contract specifically provides that the certificate of the engineer or architect shall be final and conclusive, this certificate will be accepted by the courts in the absence of fraud, gross ignorance or some other cause of equally vital nature. This is so thoroughly well established that both parties to a contract may be careless in wording the clauses concerning final estimates. As a general rule it is unquestionably best to leave the engineer or architect to act as sole arbiter of the character of work and make his certificate final. If this is the intention of the parties the decision mentioned above makes it clear that the contract must state this agreement in plain language. On the other hand, if the certificate of the engineer or architect is to be simply a preliminary step which the contractor must take in order to claim his final payments, then this fact ought to be clearly stated in the contract, and not left for determination by a long lawsuit. In the case of the Washington houses the settlement of the contract was bound to be carried into the courts, owing to the various delays by the contractor and his successors and the manner in which the work was conducted, nevertheless cases may arise where an owner might endeavor to take advantage of the contractor by the omission in the contract of any statements to the effect that the architect's certificate should be final. For this reason contractors will do well to see that some such statement is embodied in their contracts, or else that the exact nature of the proceedings to secure final payments are stated beyond question.

The Design of the Proposed Hell Gate Bridge.

The design of the great four-track railroad bridge over the East River, at New York, which was described in this journal a week ago, is a matter of more than ordinary interest in connection with the construction of great modern bridges, especially as the design as a whole is the product of combined architectural and engineering skill. It is fortunate that the designs of such structures must receive the approval of the Municipal Art Commission of the City of New York before the construction can be begun, for great bridges have too generally been considered in this country as mere "tools" of traffic. The broader idea that a great bridge should not only serve the traffic which it is to carry, but also be an object of structural beauty, satisfying the cultivated eye as well as engineering computations has been too often lost or disregarded under the "tool" point of view. There is no valid reason why a great bridge structure should not effectively serve both purposes. Indeed, it may be questioned whether the highest efficiency as a structure can be reached without leading to graceful main structural lines; at any rate, it is absolutely certain that the requirements of a graceful design may be in complete accord with the highest degree of structural efficiency. It is full time that engineers recognized these fundamental conditions in connection with their bridge design work. If the Municipal Art Commission accomplishes nothing more than a rational aesthetic control of the design of the prominent bridges in the American metropolis it will have justified its creation and earned the gratitude of the community. Its duties are difficult because of the great differences of opinion regarding artistic subjects, but at least it can accomplish much good by preventing mere utilitarianism.

These general observations have an important bearing upon the design of the proposed 1000-ft. steel arch span across Hell Gate. The illustrations published in The Engineering Record of last week show the general character of the design. It is a steel braced arch of varying depth, the minimum being at the crown and the maximum at the ends, where there is an apparent abutting against large masonry pylons to be constructed of granite and concrete. Evidently an honest and earnest effort has been made to secure a beautiful design for this bridge which exhibits a longer steel arch span than has yet been constructed. As the design is now before the Municipal Art Commission it is in a sense public property and there is no violation of professional ethics in criticising it either favorably or unfavorably. The site of the bridge is one of great prominence and the public has a right to expect not only an impressive structure in consequence of its great span and magnitude as a whole, but that it shall be graceful and conform in its treatment to some of the fundamental principles of what may be termed sensible beauty, i. e., a beauty which is in complete harmony with its entire surroundings.

While there is room for much difference of opinion in such a question as this, it may be stated that in spite of a legitimate latitude for the exercise of opinion there are some simple elements of such a general problem which should control. What will impress many at first sight is the abrupt rising of an arch from an essentially flat location where there is no apparent reason for such a structure. The main form of an arch suggests, at least to a trained eye, the idea of great horizontal pressure at the ends which find no apparent resistance in the dead level of an essentially flat bridge site. These initial impressions are much intensified if the design of the arch be such as to give it the appearance of a heavy construction, which is to a considerable extent characteristic of the proposed connecting bridge. It is true that an attempt is made to remedy this lack of visible horizontal supports, which are obviously supplied in many localities by suitable topographic features, by the great masonry pylons at either extremity of the span, but such an attempt is always forced. If these pylons could be gracefully adapted to their purpose, so as to be in harmony with the remainder of the structure, the result of the effect would be more desirable, but in the present case they can be scarcely considered happy features of the composition as a whole. The ends of the steel arches are cut square off and are neither artistic in their effect nor relieving to the engineering mind which seeks some solid mass for them to abut against. In other words, the general effect is too largely that of an ungainly structure flanked by masonry masses which do not enhance the gracefulness of the entire composition.

Ventilation Guarantees in Electrical Machinery.

In the selection of electrical machinery for any given industrial service the features of design bearing upon heat losses and ventilation deserve the most careful consideration. Reputable manufacturers are always glad to make these points clear to prospective purchasers, but sometimes there is a tendency to over-emphasize the value of cooling facilities at the expense of a somewhat reduced efficiency of operation. Obviously no commercial machine can be economically designed, manufactured and sold under competitive conditions without avoiding the use of surplus material above that needed for reliable operation within practical specified efficiencies. An induction motor might be built up of so much iron and copper that its heat losses at a certain output would be considerably below those of a competitive machine, but unless the extra cost were charged to the purchaser the result would simply be the sale of a large motor at a sacrificial price which, if persisted in by the manufacturer, would in time show a disastrous balance sheet.

Certain sensible heat losses must, therefore, accompany all electrical machinery built for definite service, and several years ago the American Institute of Electrical Engineers, realizing the importance of setting definite limits upon the temperatures allowable in good practice, drew up a series of acceptable heating guarantees for a large variety of equipment. These maximum temperature rises under various conditions of loading have since been embodied in many hundreds of engineering specifications, and are serving a useful purpose in enabling purchasers to call for apparatus well within the possibilities of economical manufacture and reliable operation. In the government service the temperature requirements tend to be more rigid—perhaps too rigorous in many cases for the actual needs of the situation—but this is a matter which should be covered by a reasonable increase in selling price on the part of the manufacturer compelled to guarantee cooler operation than the majority of commercial installations require.

Low heat losses are associated closely with high efficiency in all electrical machinery, but low temperature rises induced by artificial cooling are uncertain indices of the economy of the equipment. It is no disadvantage of a motor for heavy service that its capacity to handle the load shall in large measure depend upon artificial ventilation, but it is important that the purchasing engineer shall realize that the cool running of the machine in service does not indicate that its losses are small. Without excessive first cost and prohibitive weight many motors could not be operated successfully under purely casual methods of ventilation, and the larger the machine the more essential it becomes that the designer shall make ample provision for the disposal of the heat which is the inevitable price of transforming energy into work.

Ventilation guarantees or more accurately temperature guarantees in electrical machinery, therefore, need to be considered from more than one angle in specifying and purchasing such apparatus. Both efficiency and overload capacity depend to a large degree upon the amount of heat liberated and disposed of in a given piece of apparatus. In some cases the ability to withstand heavy overloads is worth far more to the purchaser than a gain of two or three per cent. in efficiency, and here the broader the provision for ventilation, the better are the operating results. There may be times when it pays to burn up apparatus in service rather than to fail to handle the traffic; there are other times when sustained economy of operation demands that small emphasis shall be laid upon the methods of getting rid of the heat developed, for the reason that there should be but a small percentage of energy lost in the machinery. Ventilating facilities are a good asset, but in assigning them a definite value in the purchase of equipment it is well to remember that the heat developed in the machine and not the heat dissipated is the criterion of its sufficient use of material.

The Use of Automobiles by Engineers and Contractors.

A few months ago attention was called to the usefulness of automobiles to engineers and contractors having much riding to do over roads that are fairly good. Since that article appeared, a number of readers who have given automobiles a trial have volunteered information concerning their experiences, which confirm the general statements made in this journal and indicate one or two points likely to be useful to others who contemplate experimenting with cars this year. One fact that has been pretty well established is that a sturdy automobile in the hands of a careful driver will give satisfactory service on pretty poor roads. It is manifestly unwise to attempt to learn the operation of an automobile on such roads provided better can be reached readily, but as soon as the handling of the steering wheel, brakes and change-speed lever is mastered, practice on inferior roads is helpful to every beginner. Many roads are much easier traveling than they appear at first glance, provided no attempt is made to drive over them at high speed. One correspondent even goes so far as to say that he rides more easily over rutty roads in an automobile than after a horse, as he is able to keep out of the ruts with the former, but cannot with the latter. The universal testimony is that hills offer no obstacle to the successful use of an automobile for the kind of service under consideration. One engineer who has used a light runabout in his work in a very hilly country for two years is enthusiastic over its performance and states that he could not possibly accomplish so much with horses. Some trouble has been experienced with cars where roads were mere trails across loose sand, and some experience with a car in the lowlands of a Southern State, where mud is deep and constant, indicates that the motor-car is too expensive for business purposes there. But as a general thing, cars can be run wherever carriages can be driven and can make better time. It will cost anywhere from 3 to 6 cents a mile for supplies and repairs, which is higher than the cost of driving with horses, but it is possible for a man to make so much better use of his time with a car than with horses that the mileage cost sinks into insignificance.

One thing that experience in a number of sections of the country has shown to be true is that a tonneau car is of little use to an engineer or contractor. The runabout, with a buggy top and transparent rain apron, is considered preferable for this kind of service. Such cars are lighter and more easily cared for, and compete directly with the horse and buggy which experience was firmly established as the best rig for visiting construction work. These runabout cars which are preferred for such a purpose are not the high-powered racing cars that are an almost intolerable nuisance in the vicinity of some cities just now, but are standard cars which differ from the tonneau types only in the single seat and often in a somewhat shorter wheelbase, making them somewhat easier to drive on rough roads. Where a tonneau is used it generally becomes a waste box filled with odds and ends which speedily ruin its appearance. The rear deck of a runabout affords plenty of space for carrying boxes and packages, and one engineer has had a special box made for a transit, which is placed on the running board in the same way that physicians often carry their instrument and medicine boxes. The bodies of cars are among their poorest features, and by eliminating the heavy tonneau, the useful carrying capacity of the car, except for passengers, is materially increased and the parts where wear is most noticeable are reduced in extent and complexity. It is only natural that the tonneau should be unsuited for business purposes since it has been developed for an entirely different use, and it is only recently that its shortcomings for the man who uses a car for business have become apparent.

Another point mentioned by a number of people who have used cars on rough roads is the desirability of keeping all parts as far above the road as possible. One man had to sell an otherwise satisfactory car on this account only. It is not the diameter of the wheels that fixes the car's ability to run over big stones in the road or to follow deep ruts, but the clearance below the bottom part of the running gear. The absence of a considerable clearance on most cars is one of the greatest drawbacks to their use on rough roads. Drivers accustomed to riding in carriages over such roads habitually allow their attention to wander from the height of the rocks and other obstacles in the center of the traveled way, and consequently when they run a car they are likely to be brought up with a sudden halt by the lower parts of the running gear striking against these obstacles. This is such a defect that men who have recently designed cars for the use of farmers in the West have returned to the high buggy type of construction which was developed many years ago and has since remained the most popular horse-drawn vehicle for general business use. While motor-cars of this type are hardly advisable for the use of engineers and contractors in places where roads are fairly good, the necessity of high clearance should be carefully borne in mind in selecting a car. Once or twice this subject has come up for discussion in the journals devoted to automobilism, and it has been suggested there that the proper remedy is the use of considerably larger wheels for cars for such special work. This is not a good suggestion, however, for the use of these large wheels means considerably higher expense for tires, which is high enough even under the best conditions. Any man who uses an automobile for business purposes knows that the smaller the tires the less will be the drain on his purse for repairs to them. It is a waste of money to buy anything but the best tires, and as engineers and contractors have to use their cars frequently in places where punctures and severe wear are certain to occur at disagreeably frequent intervals it needs no long discussion to show that the smaller the wheel consistent with good running qualities, the less likelihood of heavy tire expenses.

There seems to be a practical unanimity of opinion among those who have tried cars in construction work regarding the fixtures it is desirable to add to them. Everybody agrees that tire chains are very desirable. It also appears to be the general opinion that a good top with sides and front affording protection from the rain is decidedly useful. Beyond these two accessories, there is little agreement. Few of the people who have been using cars on this kind of work have any need of gas lamps and, of course, speedometers do not find favor, although one engineer finds an odometer useful. The concensus of opinion is that it is much more satisfactory in the end to put the money into a well-built car than to save in the first expense of the car and buy a lot of specialties which are mainly of the nature of spring millinery. The list of cars shows that those who have used them most satisfactorily have bought well-established makes with a reputation for fair dealing behind them. A good many people have used single cylinder cars with complete satisfaction, and there are a few two-cylinder cars from which good reports are received, particularly in New England, but for heavy work involving long runs the four-cylinder car unquestionably is preferred. In view of the preponderance of water-cooled cars that are made there is naturally less heard from the air-cooled type, but they seem to be giving satisfaction in the hands of their owners. One man who has been using one very successfully throughout the past winter states that it is a good plan when picking out an air-cooled car to insist upon a thorough test; he advises having the demonstrator run the car up a stiff hill and then at the top keep the motor running for fifteen minutes or so while the car is standing still. If the motor does not become overheated under this test he suggests that the cooling is probably sufficient to be satisfactory. He rejected one car which did not meet this test, but bought another which satisfied it completely and has nothing but praise for it.

The item of repairs is likely to run up to a considerable sum unless the car is driven by a careful man and is looked after by someone who will take the pains to keep it in adjustment all the time. Some owners report that they look after their cars themselves, while others state that they are cared for by competent employees. It goes without saying that a car must have at least as much attention as a horse and buggy, although a good many people seem to think that it is only necessary to pour gasoline into the tank, and put a little water in the plumbing to be equipped for a run of indefinite length without further attention. Most standard cars are as nearly fool-proof as somewhat complicate machinery can be made, nevertheless if accidents or serious delays are to be avoided it is necessary to keep machinery in good condition. Systematic careful inspection and prompt adjustment of all parts will keep a car running satisfactorily on very bad roads. Anybody who persists in running at a high rate over the water-breaks on hilly roads, or drives without regard to the tires is likely to have a pretty heavy expense account for springs and tires, and anybody who forgets that the car is operated by somewhat complicated machinery which needs attention will not be satisfied with an automobile for business purposes. On the other hand evidence is rapidly accumulating to the effect that if a car is given reasonably fair treatment it is likely to be an important aid to the engineer or contractor who has to cover much territory every week.

Notes and Comments.

The Los Angeles Water-Works Project, described in The Engineering Record of Jan. 26, of this year, is being steadily pushed ahead, and the annual report of the chief engineer, Mr. Wm. Mulholland, shows that considerable improvements have been made in the location of the conduit and in the proposed methods of carrying on construction. The undertaking is one of the most interesting ever projected by a municipality, for it not only calls for an aqueduct about 225 miles long, but also for a railroad, a 1,000-barrel cement plant, electric power plants, and various auxiliary works, including dams. It is proposed to use electricity to a considerable extent for construction purposes, and bids for the machinery for this plant were opened a few months ago. About 20 miles of the aqueduct will be constructed by a hydraulic dredge, and this work will be carried on by the city's own force. A railroad for use in building the works is necessary not only by the difficulty in securing enough animals for hauling, but also on account of the marked economy in handling supplies by trains. The city does not desire to construct this railroad itself, and as it seems likely that it could be made a profitable feeder for some of the existing lines, negotiations have been conducted with both the Santa Fe and Southern Pacific companies to secure its construction by one of them.

A Remarkable Well has been found by a representative of the U. S. Geological Survey near New Burlington, Ohio. It is fitted with two pumps, one furnishing fresh water and the other having such a high amount of mineral salts that it is almost brine. Two water-bearing beds confined between layers of limestone occur at this point, the upper carrying fresh water and the lower salt. The pipe of the fresh water pump is but 16 ft. long; that of the salt-water pump is 35 ft. The brine, being heavier than the fresh water, does not mix with it but remains at the bottom of the well, and the longer pipe consequently draws only the salty water.

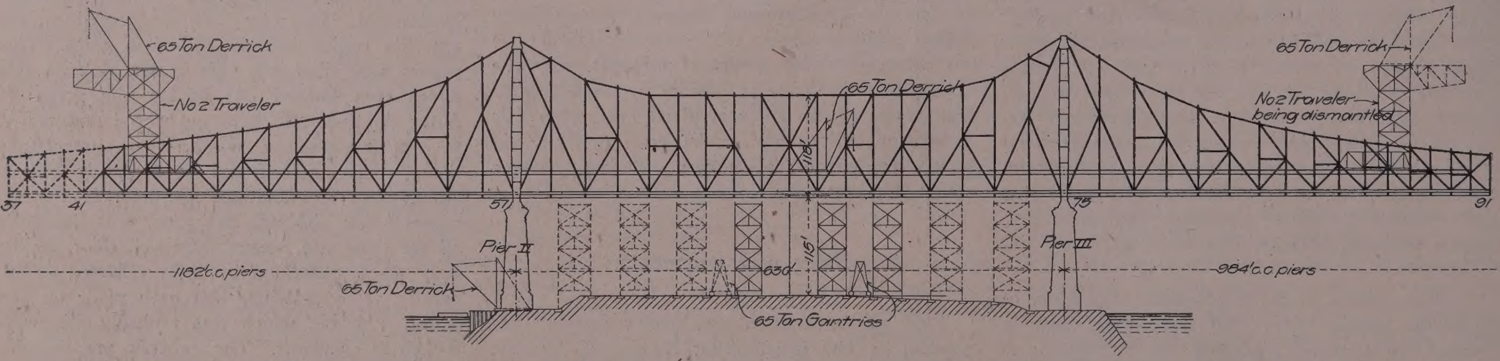
The Preservation of Maps and Survey Notes taken by the engineering department of any city has been often referred to in this journal. The occasional loss of part of these records in some places has indicated what a severe calamity the complete destruction of such papers would be, but nevertheless very few cities have taken the matter into serious consideration and consequently the continued preservation of boundary maps is a matter of good luck in most places. The recent destruction of all the records of the city engineer's office in San Francisco is a strong warning of what may happen in any place where fireproof vaults are not provided for filing them. The city engineer's notes are prima facie proof in courts concerning official surveys, and their destruction in the case of the San Francisco office would have been a calamity were it not for a remarkably fortunate fact. Some twelve years ago, Mr. Frank J. Baker, a local San Francisco surveyor, made a copy of all the surveys recorded in the city engineer's office, and since then has copied every entry made in that department. The city was resurveyed in 1862, and his copies included all that work. These papers were filed in a safe in Mr. Baker's office, which was burned out during the great fire. After the safe had been uncovered and allowed to cool for about a month, it was opened and the contents were found to be badly charred. On further examination, however, it was discovered that although the paper was discolored, all the lines and figures were still clear, particularly when examined by light reflected from a mirror. The drawings had been made on bond paper in pencil, which was probably the reason for their clearness. The records are therefore intact, and Mr. Baker has just completed copying them in books, about a thousand volumes being filled with the data. This is the only complete set of boundary records now in existence in San Francisco, and it is consequently of the highest importance to the owners of real estate as well as to the city. In fact its actual cash value can hardly be estimated, and the labor which Mr. Baker spent upon the work years ago is likely to be extremely profitable to him. Were no such copy of the records in existence, the litigation over property rights might become a great burden on the city's development.

PROGRESS OF THE BLACKWELL'S ISLAND BRIDGE ERECTION.

The official report of May 11, 1907, on the condition of the Blackwell's Island bridge, shows that the west half of the 984-ft. cantilever span over the east channel of the East River and fifteen of the twenty panels in the east half of the 1,182-ft. cantilever span over the west channel of the same river have now been assembled, and, together with the previously completed 630-ft. island span, which connects them, comprise 1,600 ft. of the 1,713-ft. continuous trusses and about 47,000,000 lb. of steel in this portion of the superstructure. Pier No. II, is at panel point 57 and the 500-ton steel traveler No. 2 has been advanced to panel point 43, and has nearly completed the double panel 43-41 in advance. The duplicate traveler which has completed the erection of the opposite arm over the east channel has been moved back to panel 85-87 and is being dismantled for re-erection on the Manhattan shore. The 1,700-ton steel falsework for the island span between piers II and III has now been entirely released by the weights of the cantilever arms which have operated to reverse the cambre in the island span, and it is now being taken down and conveyed to the Manhattan shore where it is re-erected for the erection of the 469-ft. 6-in. west anchor arm span.

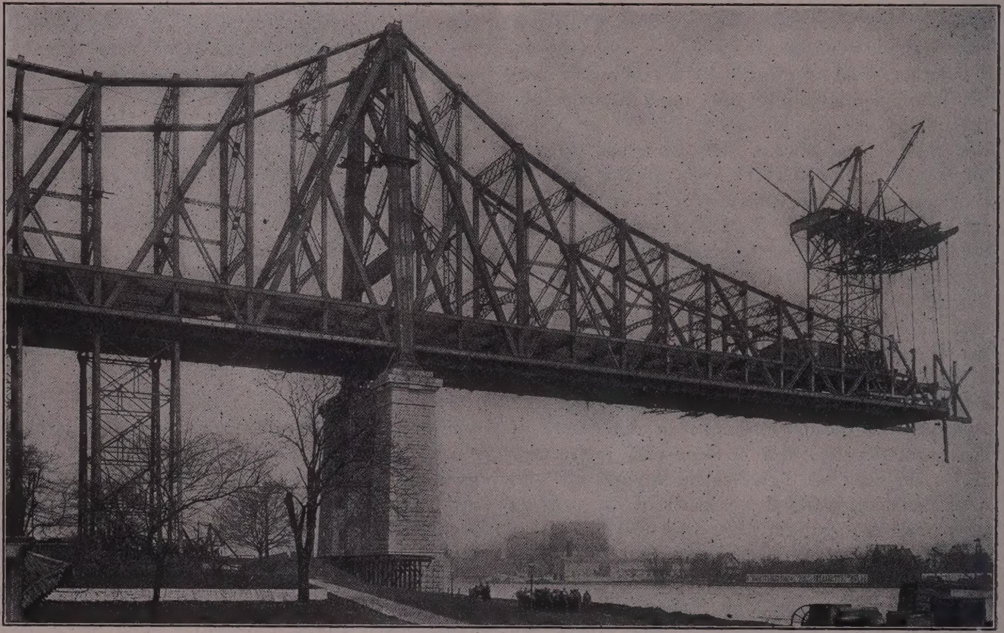
As described in a previous article, the varying conditions of erection stress and corresponding positions of the members of the superstructure made it necessary to incline each of the main bents over piers II and III, toward each other at the top when erected, springing them transversely by means of telescopic members operated by 70-ton jacks. As the cantilever arms were built out the final dead load stresses have been developed in the island span and these posts have assumed nearly their final position, being now in a vertical plane on Pier III.

The material for the 591-ft. cantilever, like that for the opposite cantilever and the connecting spans was all delivered by barges to the 65-ton steel derrick at the foot of Pier II, stored by the two gantry cranes shown in the rear of the falsework, and delivered by them to service cars carrying it underneath the channel span where it was hoisted by a 65-ton boom derrick seated on the upper deck and loading it on standard-gauge flat cars on trucks on the cantilever extensions outside the trusses which carried it to the travelers, thus enabling it to be assembled with the maximum rapidity and convenience. The largest piece yet handled has been the 78-ton, 105-ft. half of the main diagonal. The best record has been the erection of 783 tons in the week of March 16-23 when the travelers were at work simultaneously on both anchor arms.



Island Span and Cantilevers. Light Dotted Lines Show Erection Plant Dismantled by May 11.

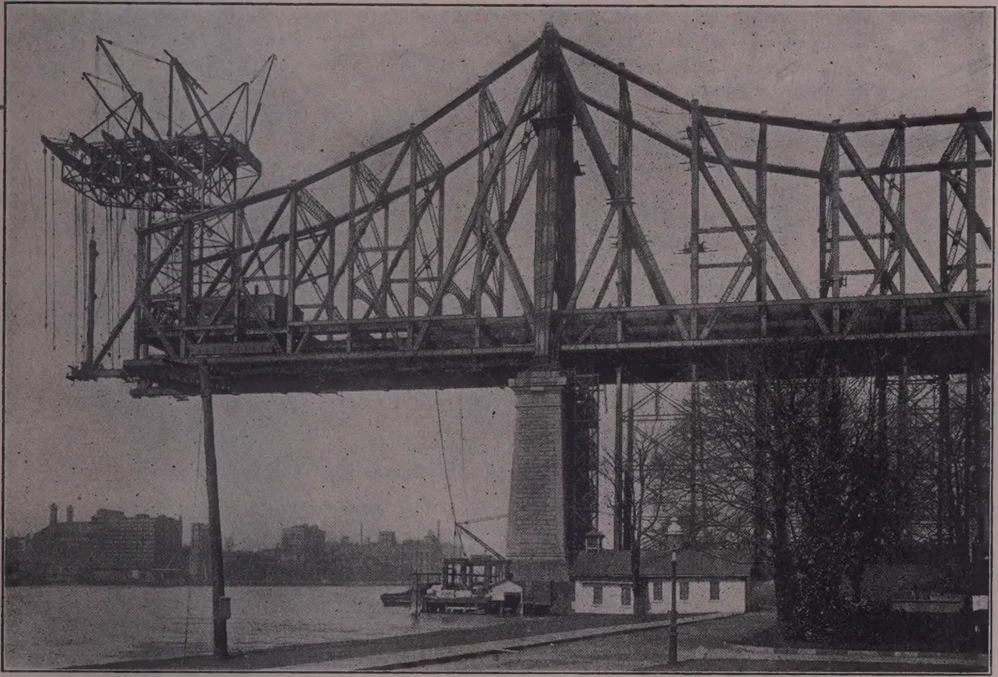
An average force of about 500 men is now employed and includes 22 four-man riveting gangs, who up to May 6 have driven about 151,500 field rivets, most of them ⅞ in. in diameter. They are preceded by two five-men scaffold gangs and one four-man fitting-up gang, who usually run a taper fluted pneumatic reamer through every hole to make sure that it is perfect, although generally they are found to be extremely well matched. The work is done with pneumatic hammers and reamers of the Cleveland, Philadelphia and Green types, with flexible connections about 50 ft. apart to two lines of pressure pipes reducing from 4 in. diameter at the power plant to 1½ in. diameter at the extremities of the cantilever arms. A gang of about 20 men is constantly employed in applying the first coat of red lead paint with flat brushes. This is often put on before the members are hoisted from the ground and care is taken to go over the work and touch up all rivet heads driven after painting.



Cantilever over East Channel.

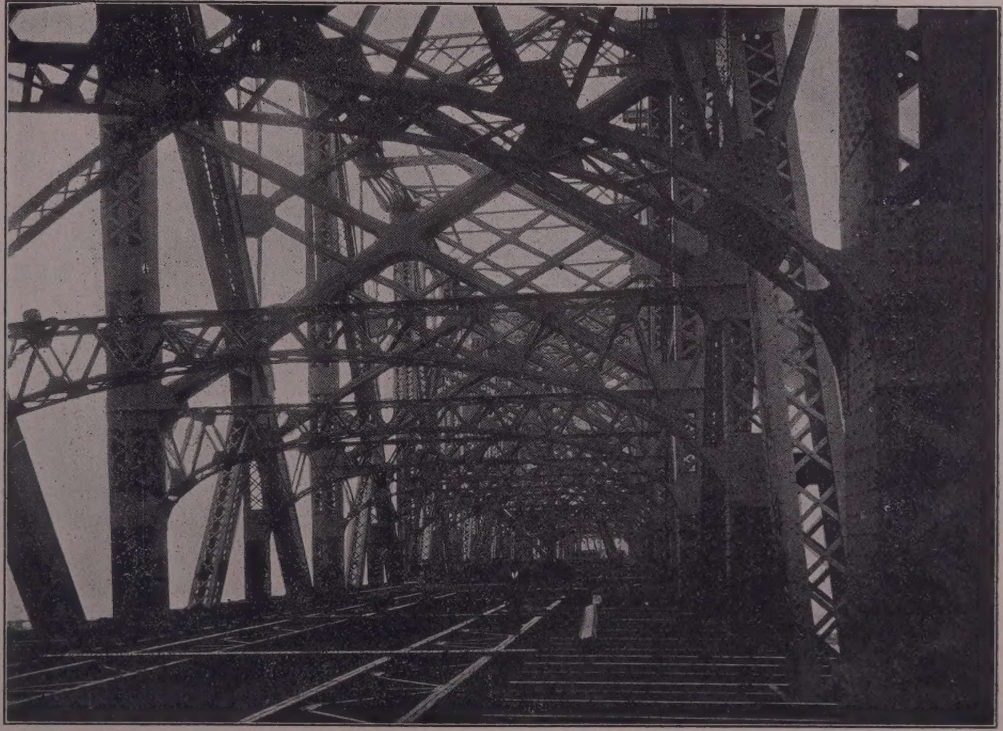
Field riveting has not yet been commenced on the cantilever arms, but for the Island span it is complete except for the lower chord splices, bottom laterals, and buckle plates. The box girders on the main piers which connect the bottoms of the inclined post are to be connected under an initial stress and the large number of field rivets in their splices will not be driven until the temperature is moderated. The bottom chord splices will be riveted at any convenient time as soon as possible after the completion of the cantilever arms produces the final dead load stresses in them.

There are in all about 100,000 field-driven rivets in the island span, and although they are proportioned on the assumption that their efficiency is only about 75 per cent. of that of the same number of shop-driven rivets, they are driven with such care that it is believed that they are in reality nearly or quite as good as the shop-driven rivets. The holes vary from about 1 in. to 3 in. in length and are carefully matched and reamed to a clearance of only about 1/16 in. for cold rivets. The rivet lengths vary ⅛ in. from exact measurements and are made 1¾ to 2 in. longer than the lengths of the holes to allow for heading. The rivets are heated in lots of about one dozen to a light yellow temperature in portable coke furnaces with compressed air blast throttled down to the required force by ordinary gate valves in a 1-in. pipe. The rivet heater regularly feeds the rivets from one side to the center of the furnace and removes them in the same order, taking the hottest rivet after it has remained in the furnace for a minimum period of 2 to 5 min., care being taken to reduce the blast if the riveting is materially delayed. The rivets are carried in the tongs a short distance from the furnace to the point driven, or if necessary are thrown to upper scaffolds where they are caught in boxes or pails. They are held up by one man with a straight or special dolly bar or by a pneumatic bucker, and are driven by two men operating the pneumatic hammer, which weighs about 25 lb. and makes about 1,800 strokes a minute. The driving is continued until the rivet cools to a very dull red or nearly black and great pains are taken to make a perfect concentric head. They are rigidly examined by an inspector, who tests them all for tightness, but it is not ordinarily necessary to condemn more than about nine per cent. of the rivets driven. The most troublesome rivets to drive are those at the middle splices of the vertical and diagonal posts, where it is more difficult to provide scaf-



Cantilever over West Channel.

folds than for other parts of the work. These members have three and four webs with single and double cover plates on both webs and flanges, most of which are shop-riveted at one end and field-riveted at the other, making totals of 100 to 300 field-driven rivets at each splice. Some of the rivets through the center webs are very difficult to drive and a few of them are so inaccessible that they cannot be driven and the holes are therefore filled with bolts. There are also a large number of field rivets in the diaphragms of these members, but in the most confined cases the diaphragms are made with pairs of overlapping angles shop-riveted to the post web and field-riveted through their outstanding flanges, which are more accessible than rivets driven in the opposite direction. Connections for the transverse struts and sway braces are made with wide connection plates riveted to the flanges of the vertical posts and the field-driven rivets in them are usually accessible and easily driven. The bottom lateral diagonals are all I-shaped X-braces, with their top and bottom flanges field-riveted to horizontal connection plates field-riveted to the chords, floor beams and transverse struts. Maximum stresses of 2,000,000 lb. have to be transmitted to some of these connections which require a large number of rivets arranged in from two to five staggered rows for each line. Over 200 field-driven rivets are required at each end of the end lower lateral diagonal.



Transverse Bracing above Upper Deck.

The lower lateral diagonals extend across two panels, intersecting on the center line of intermediate floorbeams, which they are cut to clear, and where they are engaged between top and bottom horizontal connection plates. The bottom connection plate, nearly 6 ft. square and ⅝ in. thick, is symmetrical with the bottom flange of the floorbeam to which it is connected with 30 field-driven rivets. On each side it is reinforced by two filler plates and has 60 field-driven rivets in the lower flange of each portion of the diagonal. The upper flanges of the diagonals are field-riveted to horizontal plates about one-half as large as the bottom plate, which are field-riveted to connections on both sides of the floorbeam webs.

The bottom chords 5 ft. wide are made with four built channels 4 ft. deep, spliced clear of the panel points with double plates on each web, and with single long top and bottom flange cover plates. Part of the web plates are shop-riveted at one end, but all of the other rivets are field-driven, making from 300 to 400 at each splice, some of them as much as 5 in. long between heads.

The box girders on the piers are about 10 ft. wide and 4 ft. deep and are made with three sections spliced with web and flange cover plates having about 700 field rivets in each splice. There are besides a large number of field rivets in the diaphragms and lateral connections, but the connections at the ends of the girders are made with flange plates bolted between the sections of the cast steel pedestals.

The top and bottom floorbeams are connected to the vertical posts with pairs of vertical angles shop-riveted to the floorbeam webs and having about 50 easily accessible field rivets to the vertical post. The lower floorbeams are extended outside of the trusses by solid web cantilever projections 13 ft. long connected to the vertical post in the same manner as the regular floorbeams and having pairs of flat horizontal tension bars engaging the webs above the top flanges. These bars pass directly through the vertical posts and are field-riveted at both ends to the main floorbeams and to their extensions. The stringers are field-riveted together in the usual manner through vertical end flange angles and through the floorbeam webs.

The bridge was designed and is being erected under the direction of the Department of Bridges of New York City. The Pennsylvania Steel Co. is the contractor for the fabrication and erection of the superstructure.

Reinforced Concrete Tests.

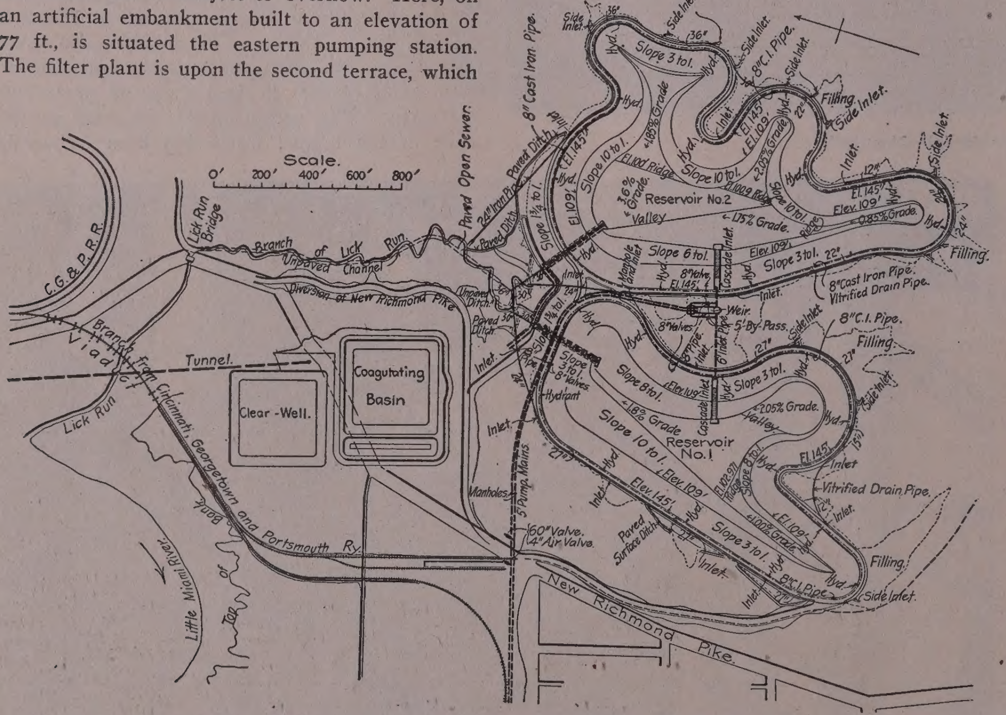
Reinforced concrete tests made at the University of Wisconsin testing laboratories during the past four years indicate that concrete cracks before evidences of the break can be detected by the eye, and that after it has cracked, though only minutely, its strength in tension is zero. Comparative tests of reinforced and plain concrete bars made at the university show that the first indication of cracking appear on the reinforced beams at about the same load at which the plain beams fail. It is therefore considered probable that concrete reinforced with steel will not stretch more before cracking than plain concrete and that consequently the tensile resistance of concrete should not be taken into consideration in reinforced concrete design. A discussion of the subject has recently been published by the university, in a form of a bulletin prepared by Mr. E. A. Moritz. This bulletin also gives information concerning tests made in the laboratory to determine the best form of steel reinforcement. The anchoring of the rods at the ends of the beams, which has been frequently advocated, did not seem to strengthen them materially. The experiments apparently demonstrate that the cracking in the plane of reinforcement is not due to the pulling out of the rod, but rather to the pulling of the concrete upward away from the rod, and that it therefore cannot be prevented by anchoring the rod at the end. In most reinforcements with bent rods, the angle of these rods with the horizontal has been too large and the area of the rods too small.

The Settling Reservoirs of the New Cincinnati Water-Works.

By William C. Jewett, M. Am. Soc. C. E., Resident Engineer.

The settling reservoirs of the new water-works of Cincinnati are located near the village of California, Ohio, 8 miles above the center of the city. The Eastern pumping station is on the northern bank of the Ohio River, one-half mile from the reservoirs, while opposite, in the Kentucky side of the river channel, is the intake pier, the two being connected by a tunnel 7 ft. in diameter, under the river. The filter plant is situated in the immediate vicinity, and is connected with the western pumping station, which is at Torrence Road, by a tunnel 4½ miles long and 7 ft. in diameter. The water will be pumped from the western pumping station through a 60-in. main to the Eden Park reservoir and through a 48-in. main to the high service on the hills, the residential portion of the city.

At California, the valley of the Ohio River was eroded previous to the last glacial period to a width of 1½ miles and to a depth of 40 ft. below the present bed of the stream. The valley is now partially filled with glacial drift in the form of three terraces on the Ohio side, while the river flows against the Kentucky hills in the extreme southern side of its original channel. The lower terrace, on which is the village of California, is at an elevation of 60 ft. above low water and is subject to overflow. Here, on an artificial embankment built to an elevation of 77 ft., is situated the eastern pumping station. The filter plant is upon the second terrace, which is at an elevation of 100 ft. and is not defined at all points along the river. The third and upper terrace is at an elevation of about 165 ft. and is very much eroded, so that the average elevation is much lower. On this terrace are located the settling reservoirs.

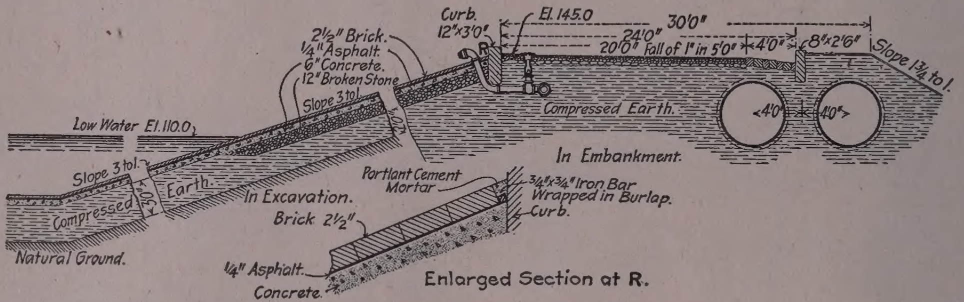


General Plan of the Settling Reservoirs at California.

The topography of this locality is such as to afford an excellent site for artificial reservoirs, for they can be constructed at a minimum cost. Two ravines practically parallel, 2,000 ft. long and separated by a high, narrow ridge, form an ideal location for reservoirs where it is desirable to have two, to be used alternately for settling purposes.

For outlining the general plan for the location of the entire plant a preliminary topographic survey was made in 1897 and platted to a scale of 200 ft. to the inch, with contours indicated every 5 ft. After the adoption of the general design of the plant, a more accurate survey was made of the site during the winter of 1897-8, for use in designing the reservoirs. For this survey a system of rectilinear coördinates was adopted. The method of laying out this system was as follows: The main base line was first established for the entire survey. At right angles to this another base line was laid out along the ridge between the reservoirs, from which large rectangles, the size depending upon the topography, were established and checked a number of times. The error in closing was made as small as possible with very careful steel-tape measurements, the maximum error permitted being 0.003 in 100 ft. All measurements were made on hubs, using plumb-bobs, and hand levels for leveling the tape line. In all measurements, corrections were made for temperature. The large rectangles were filled in with rectangles 100 ft. square and hubs set at the intersections. The east and west lines were designated Y and the north and south lines X, the zero of each being assumed beyond the limits of the proposed work. By this system the location of any point or structure is easily described and found on the ground. Every hub was referenced with a stake giving the coördinates. Hard wood hubs 2½ and 3 ft. long were set every 100 ft. on the base line between the reservoirs and at all important points outside of the area of the reservoirs that would be required for future work in replacing lost points and other permanent points for use in construction. The 100-ft. rectangles were divided into 50-ft. rectangles by setting ordinary stakes for use in taking topography. The topography was taken by means of regular cross-sections with a level party of five men. Each rectangle was divided as often as necessary for taking accurate cross-sections. Every elevation taken was recorded by its coördinates. The sections were generally taken along the coördinate lines that were nearest at right angles to the slope of the ground. These sections were taken with sufficient accuracy for use in making final estimates. An area of over 100 acres was cross-sectioned in this manner. A system of bench-marks was established over the area and very carefully checked in order to have benches for closing in on every run of the levels. The datum plane for elevations was taken from the low water mark of the Cincinnati water works.

A plat of each reservor was made to a scale of 50 ft. to the inch. All points at which elevations were taken were indicated by a pencil point and the elevations marked, and contours were interpolated 2 ft. apart, at elevations of even numbers. On these plats the reservoirs were laid out with a view of having the excavations equal the embankments as nearly as possible. Many trials were made before the final outline was determined. The estimates for these trials and the approximate estimates for the letting were made from the plats with a planimeter, using horizontal sections 2 ft. apart. The top of the reservoir was fixed at El. 145 ft. and low water in the reservoirs at El. 110 ft. Between El. 145 and El. 109 the slope is 3:1 while below this are lighter slopes 6:1, 8:1 and 10:1, depending upon the topography, intersecting the bottom planes. The bottom planes slope from the lower end of the reservoirs at El. 89 to the upper end at El. 109 on gradients which vary from 1 to 3.6 per cent. Most of the alignment of the outline being circular curves, we have for the 3:1 slopes conical surfaces; the 6:1, 8:1 and 10:1 intersecting at El. 109 give another set of conical surfaces of different slant from those forming the 3:1 slope. About the center of the dam which forms the lower end of the reservoir, the 3:1 slope extends to the bottom at El. 89. This makes it necessary to connect the lower system of cones with the 3:1 slope on each side of the dam. This connection is effected by the use of elliptical conic surfaces.



Lining of Slopes of the Settling Reservoirs.

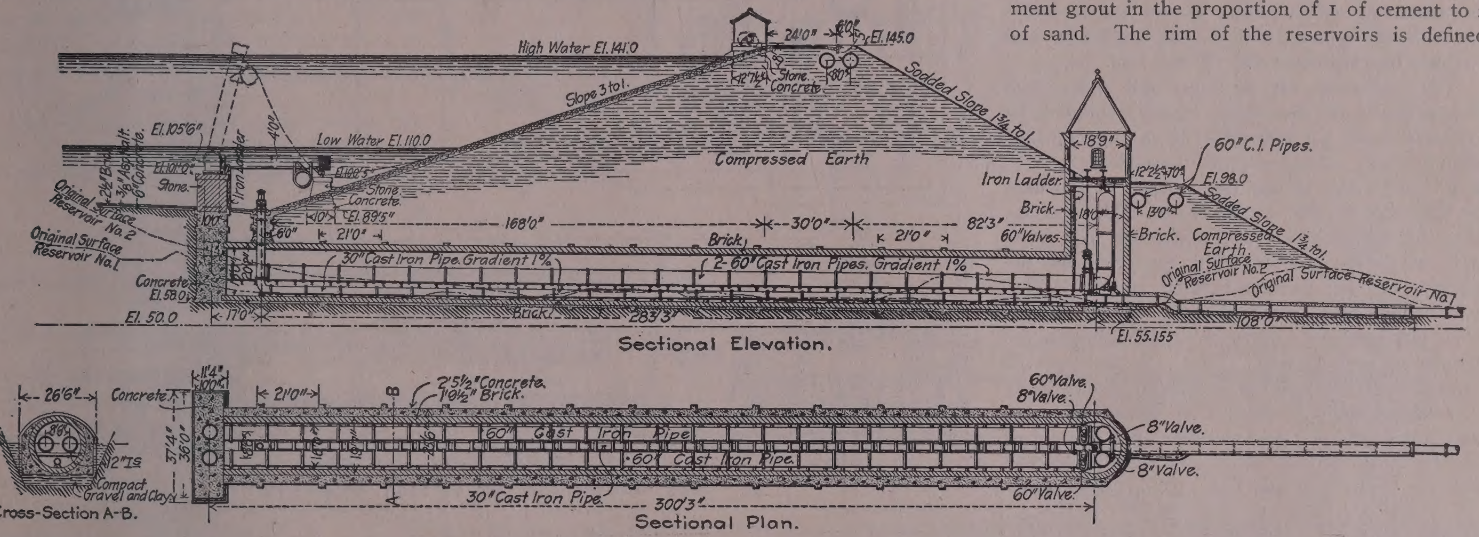
The dam is 30 ft. wide on top with an outer slope of 1¾:1 and with a 30-ft. berm at El. 98. As the ravine below the berm will be filled with waste material, it will have the 1¾:1 slope only between El. 98 and El. 145, a height of 47 ft. The back of the two dams will form a continuous surface about 1,200 ft. long, the angle at the intersections of the two slopes being filled with a cylindrical surface. The maximum height of the dam is 89 ft.

For use in the construction of the reservoirs a base line was adopted 15 ft. outside the rim and parallel to it. In establishing this line, the coördinates of the points of curvature and the tangent points were calculated and located by triangulation, and were carefully referenced. It was found for construction purposes that this line was more convenient than the coördinate system, for on the conical surfaces all work could be done on the radii and circumference of the intersecting horizontal planes. For the estimates, cross-sections are taken radially on conical surfaces; the centers of gravity of each section are determined by platting the sections on cardboard, cutting it out and balancing the section on a needle. This work is only necessary on embankments, as all earthwork is paid for in embankments only. For the bottom cross-section convenient base lines are established.

All excavations are taken down to a plane 3 ft. below the bottom of the concrete revetment. The stripping, consisting of soil and vegetable mold, is either piled for future use in sodding slopes or placed in depressions. Across the ravines, dams are built and the depressions above are filled nearly up to El. 145 so as to drain into the sewers. All embankments for a width of 30 ft. on top and with 1¾:1 slope on the back are built in 4-in. layers, spread to a uniform thickness and rolled with rollers weighing 13½ to 14½ tons. For ordinary materials the roller passes over each layer from six to eight times. The better material is used on the inside face of the embankment and the poorer on the outside. A blanket of clay is placed on the entire surface of the reservoirs and is 2 ft. thick on the 3:1 slope and 3 ft. thick on the lower slope and bottom. It is built in 4-in. layers and rolled the same as the other embankments. For a short distance at each end of the dams the clay blanket will be much thickened on account of the sandy formation. On the lower end of the ridge between the reservoirs adjacent to the dams for a distance of about 400 ft., the clay blanket will be 11 ft. thick, and at the other end of the dam for a distance of about 400 ft. it will be 5 ft. thick. As stated before, the material is glacial drift. The surface is a fine reddish colored sandy clay with the sand predominating; below this is a stratum of brown clay full of limestone slabs and limestone fragments, and then a bed of sand and gravel. In the gravel is a stratum of conglomerate varying from 10 to 20 ft. in thickness. In places this crops out as a ledge of conglomerate, but going inward from the face of the ravine the ledge gradually changes to a conglomerate boulder formation and finally disappears. At the lower end of the reservoirs, the formation is very irregular, with clay and sand in pockets. Part of the conglomerate was saved and crushed for use in the rock revetments and roadways. When the clay blanket is finished and trimmed to a true surface, the 3:1 slopes will be covered to a depth of 12 in. with a frost-proofing composed of 2½-in. crushed stone unscreened or gravel with the voids filled with sand.

The entire surface of the reservoirs is then covered with concrete 6 in. thick. This concrete consists of 1-in. crushed stone, unscreened gravel or 1-in. river gravel, river sand and Atlas Portland cement, in the proportion of one of cement, two of sand and four of stone or gravel. When properly mixed this gives a rich concrete and is in the proper proportion for revetment work, or any other surface intended to hold water. In order to provide for expansion and contraction in the concrete, parting joints are made 3-in. deep, ⅜-in. wide on top and ⅛ in. wide on the bottom. The joints are laid out in hexagonal sections with sides 12 ft. long. They are temporarily filled with yarn to keep them clean until ready for the asphalt. Before the asphalt is placed, the surface of the concrete is primed with a coat of asphalt and benzine in order to make the asphalt adhere. The parting joints are then filled with asphalt. A coat of asphalt about ⅛ in. thick is spread over the surface of the concrete, on top of which burlap is spread. This is held in place by an iron rod set against the curb. On the burlap another coat of asphalt is spread until the combined thickness of the asphalt and burlap is ¼ in. Just before placing the bricks, in order to soften the surface of the asphalt, it is primed with a coat of asphalt and benzine. The bricks are laid herring-bone with ¼-in. joints which are filled with Portland cement grout in the proportion of 1 of cement to 2 of sand. The rim of the reservoirs is defined by a sandstone curb 12 in. wide and 3 ft. deep, set with the top 9 in. above the concrete.

The supply of water is carried through two lines of 60-in. cast iron pipe, laid from the eastern pumping station and passing over the dam of Reservoir No. 1, thence along the ridge dividing the two reservoirs to a point about one-third of the length of the reservoir from the dam. At this point a weir with a runway 70 ft. long and a notch 15 ft. wide is constructed for measuring water, from which a 72-in. pipe leads to each reservoir and discharges into a chamber at the edge of the reservoir. From this chamber a cascade 18 ft. wide will be constructed on the slope, extending to the bottom of the reservoir. The weir will be of sandstone masonry construction, while the cascade is to be of concrete. Sixty-inch bypasses are laid around the weir, so that

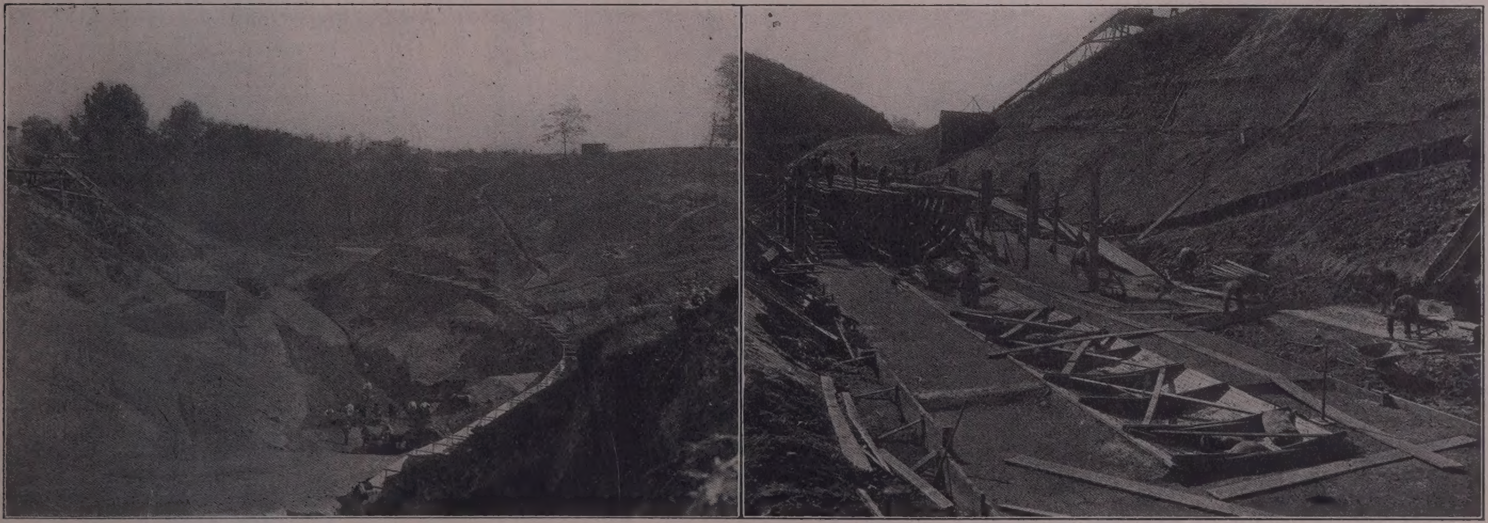


Sectional Elevation.

Cross-Section A-B.

Sectional Plan.

Plan and Section of Reservoir Embankment at Archway.

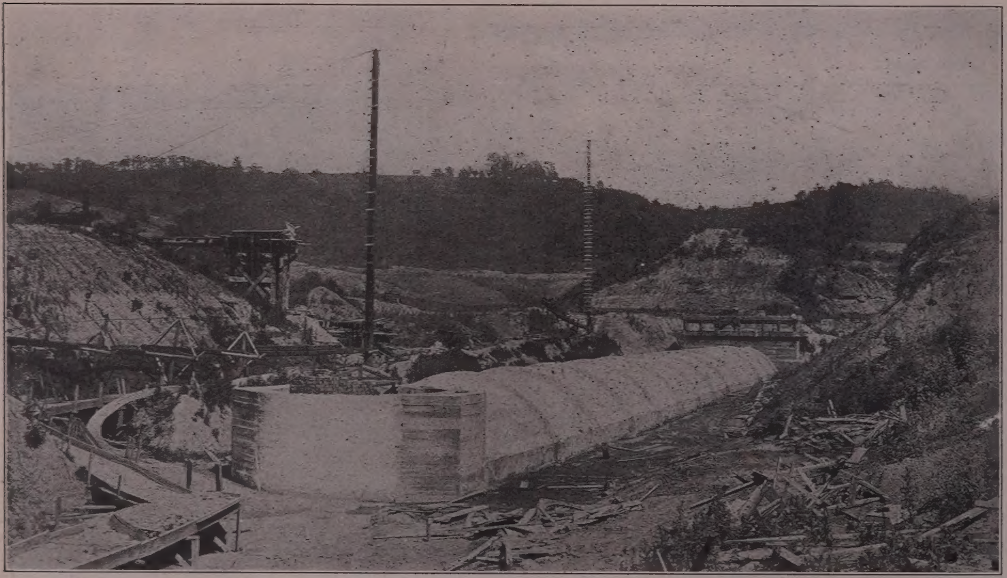


Preparing Foundations and Laying Invert for Archway No. 1.

it may be thrown out of service. A spillway will connect the two reservoirs to prevent the possible danger of overflowing. It is planned to have only one reservoir full at a time.

Two effluent pipes from each reservoir, each 60 in. in diameter, will carry the water from the reservoir to the filter plant. These pipes are carried under the dam, through a circular archway 10 ft. in diameter and 300 ft. long, then up to the 98-ft. berm through a shaft 18 ft. in diameter. The pipes are accessible at all points except the vertical portion in the bottom of the reservoir, which is within a concrete pier 10 ft. by 36 ft. in size. The water is admitted into the pipes through two floating tubes connected with the 60-in. pipes by a hinged joint. These tubes are horizontal at low water. They are to be operated, so as to take water at about 4 ft. below the surface, by means of a cylindrical float and a chain operated by crabs on the dam.

The archways are circular, and built with five rings of vitrified shale brick surrounded by concrete 2 ft. 5½ in. thick at the spring line, with vertical sides from the foundation to 2 ft. 4 in. above the spring line, thence diminishing in thickness to zero at the crown. The foundations for the archways were excavated to a plane 3 ft. below the bottom of the concrete. All the pockets of clay were excavated and back-filled with sand of the same kind as the foundation. Test pits were dug every 50 ft. to ascertain the nature of the material. The 3 ft. between the sand foundation and the bottom of the concrete were filled with a mixture of gravel and clay and rolled with a 14½-ton roller. The method of constructing archway No. 1 was as follows: The concrete invert was first built, using forms. Ransome and cubical concrete mixers were used. The concrete was composed of 2-in. river gravel, river sand and Atlas Portland cement in the proportions of one of cement, two of sand and four of gravel. The mixers were turned 25 times and the concrete was made rather wet. The concrete invert was followed by the construction of the brick invert and the setting of the I-beams for the support of the 60-in. effluent pipes. After the completion of the invert the 30-in. drain pipe was laid in the bottom and the double line of 60-in. pipes were laid on the I-beams. The arch was then sprung and the concrete spandrel filling built. In order to roughen the surface of the archway and thereby prevent the water from finding a pathway along the surface of the structure, it was surrounded at intervals of 21 ft. by concrete ribs 12 in. by 18 in.

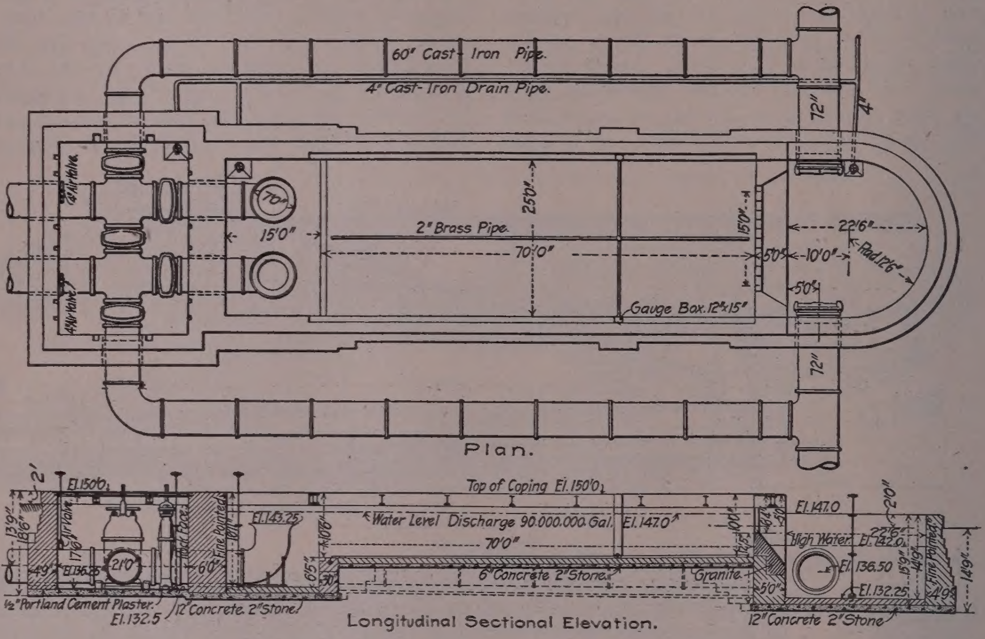


Archway No. 2. after Completion.

For emptying and cleaning the reservoirs an outlet system is provided, consisting of 30-in. drain pipe laid from the bottom of the reservoir at the lower end, passing vertically through the crown of the arch and extending along the invert and out under the dam to the valley. The opening of this drain will be controlled by a 30-in. hydraulic mud valve. There will be three additional openings in Reservoir No. 1 and four in Reservoir No. 2 at central points in the bottom. These will be connected with the 30-in. pipe by 24-in., 20-in. and 16-in. pipes laid about 3 ft. below the bottom of the concrete.

The water supply to be used for cleaning will be carried through an 8-in. and 10-in. water line laid around each reservoir under the roadway surrounding them and 5 ft. 6 in. back of the curb. Four-inch hydrants will be provided every 300 ft., just inside of the curb. The washing will be done with hose, provided with a suitable nozzle and a special pump for giving a high pressure.

Around each reservoir a complete system of drainage has been built. Sewer pipe from 12 in. up to 36 in. was laid, except in steep grades, as the descent from the upper level to the valley of Lick Run, where 24-in. cast iron pipe was used. The sewers all empty into an open sewer 250 ft. long and 5 ft. deep. Immediately over the sewers is a paved ditch with vertical inlets every 400 ft. The inlets are built of brick and capped with a concave cast iron grating. At points where the drainage areas are too large for the vertical inlets, lateral sewers were laid beyond the limits of the embankments, and side culvert openings provided. The openings vary from 15 to 30 in. in diameter and are protected with iron gratings. The minimum gradient of the sewer line is 3 in. per hundred feet and the sewers are proportioned to take a rainfall of 3 in. per hour.



Weir between the Two Settling Reservoirs.

A graded roadway 30 ft. wide will surround each reservoir. Between the curb and the paved ditch will be constructed a macadam drive 20 ft. wide, having a slope of 4 in. in 20 ft. from the curb to the gutter. This roadway will be connected with the Columbia and New Richmond Turnpike.

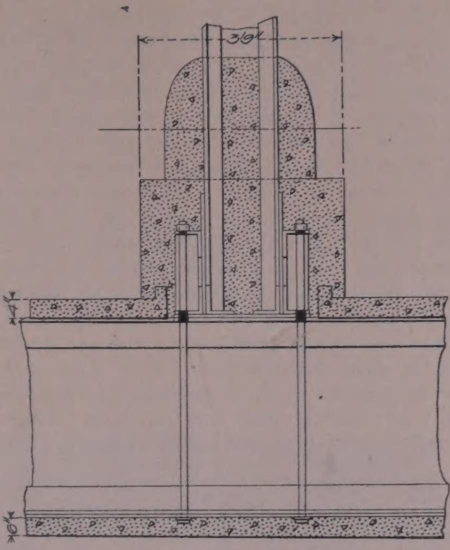
The two reservoirs cover over 45 acres, and the distance around each is about one mile. The total capacity of Reservoir No. 1 is 184,000,000 gal. and that of Reservoir No. 2 is 222,000,000 gal., while the available capacity is 158,000,000 gal. for No. 1 and 187,000,000 gal. for No. 2. The reservoirs are to be used alternately and hold about seven days' supply. The total cost of the two reservoirs and the force mains will be very close to $1,323,000.

A Reinforced Concrete Ore Dock is now under construction on the Cuyahoga River for the Cleveland Furnace Co. The work is being done at the site of an old dock, which had a row of sheet piling 11 ft. back of the center line of the new river wall. This sheet piling is tied back to anchor piles some 20 ft. inland from it. The wall of the new dock rests on two lines of wood piles on 2½-ft. centers longitudinally and transversely. A bed of concrete 22 in. thick rests on the heads of these piles and supports the wall, of dumb-bell shape, having a thickness of 16 in. in the web and widening at the top so as to overhang the water about 3 ft. This cantilever is supported by 16-in. brackets every 15 ft., which run down to the concrete base and form substantial counterforts. Behind the wall the concrete base is carried back to the old sheet piling in the form of a reinforced slab about 6 in. thick. This slab also supports buttresses running to the top of the river wall and spaced 15 ft. apart. The space between the old and new walls will be filled with slag. The new wall will have to carry the outboard end of the traveling unloading machinery, which will impose a load of 53,000 lb. upon it. The design and construction of this wall has been entrusted to the Carey Construction Co., of Cleveland.

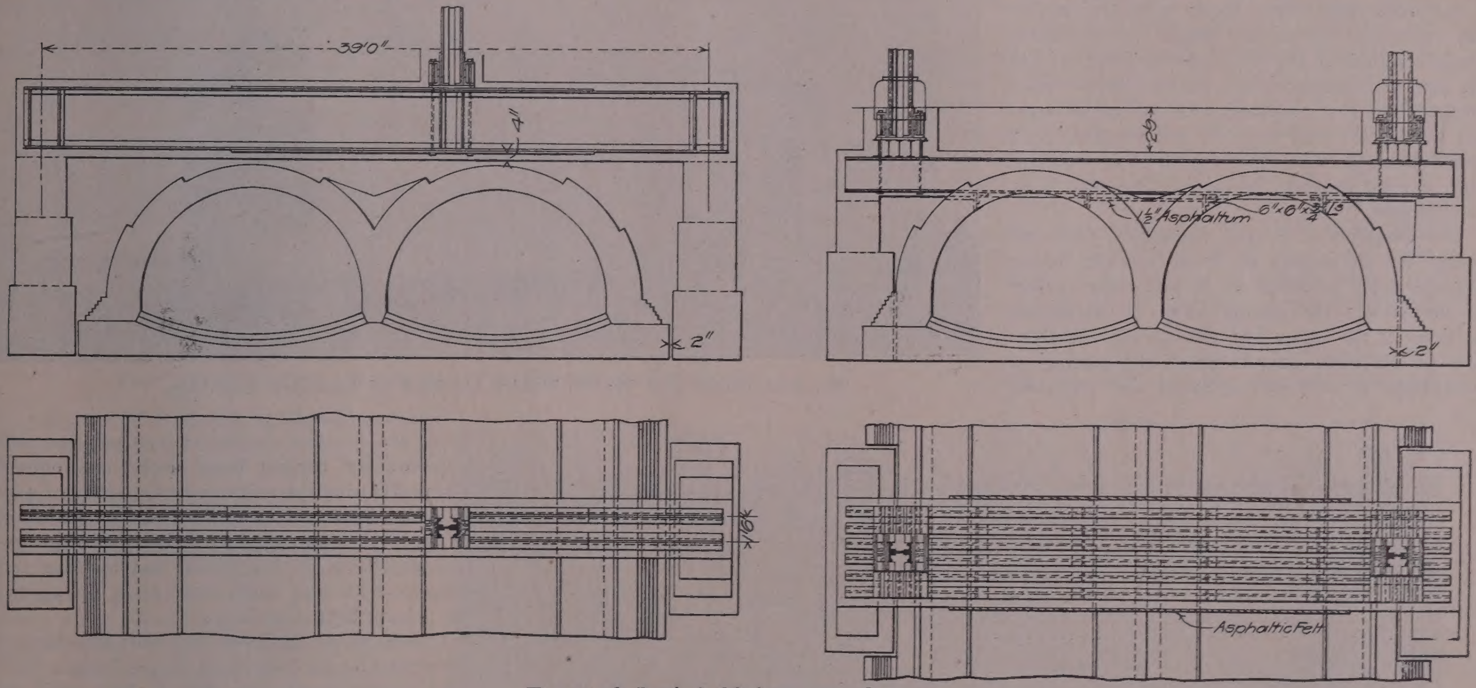
Constructing Elevated Railroad Foundations Over a Large Sewer.

The Van Cortlandt Park extension of the New York Rapid Transit Railroad system is a standard three-track steel viaduct located for about 1 mile north of 230th St., approximately on the center line of Broadway, which is there a new street recently filled in to a height of about 15 ft. above the original surface. The embankment encloses a large brick sewer made with twin conduits about 14½ ft. apart on centers with duplicate flat horseshoe shape cross-sections about 9 ft. high and 15 ft. wide inside. They are separated by a center wall 18 in. in minimum thickness, and their inverts rest on a continuous concrete footing having a nominal average width of 32 ft. and carried down to rock or good gravel with a depth varying from 3 to 12 ft.

The elevated railroad spans are carried by two lines of steel columns averaging about 53 ft. apart longitudinally and in most cases 29 ft. apart transversely. As the axes of the elevated railroad viaduct and of the sewer are not in all cases exactly coincident, the relative locations of the columns and of the sewer arches vary somewhat, but in most instances both of the columns come between the outer edges of the sewer footing. It was not only required to support the elevated railroad absolutely independent of the sewers but to separate the foundations of the two structures so thoroughly that it would be impossible for any vibration to be transmitted from one to the other.



Concrete Flashing of Column Bases.



Types of Buried Girders over Sewer.

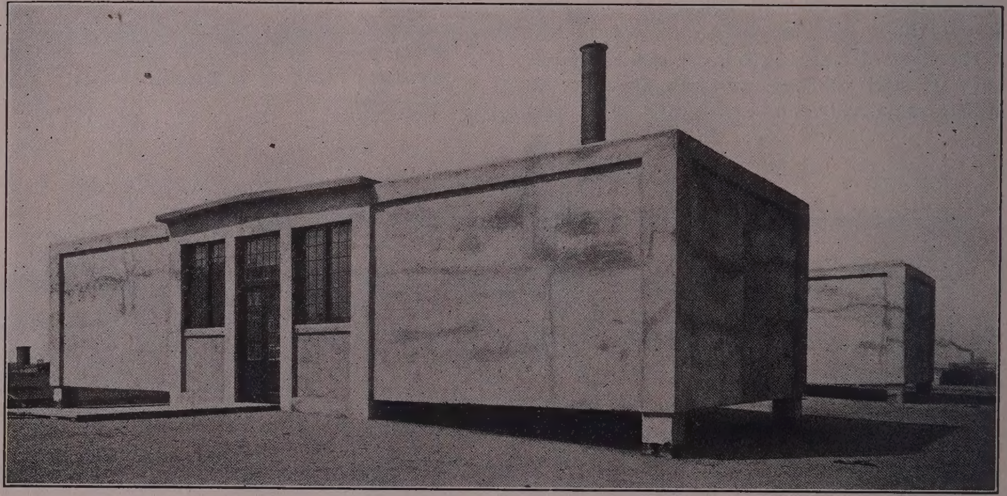
In order to maintain the positions of the columns in proper relations to the curb lines and to avoid excessive lengths of transverse spans of the superstructure it was decided to support them over the sewers on heavy transverse girders buried below the surface of the street and seated at both ends on independent concrete piers carried down to solid rock wherever possible and maintained scrupulously separate from the sewer footings. The varying conditions were met by designs which may be classified into three general types, viz: where one column is carried between the girder piers; where two columns are carried between the girder piers; and where one column is carried on a cantilever projection of the girder. These types are farther modified by the clearance between the top of the sewer arch and the surface of the roadway so that there were in all eight different cases, most of them having several examples with different dimensions, making in all thirty-five different girders for the 100 transverse bents included on this section of the work. In all cases except K, the new piers, in the plane of the transverse bent of the superstructure, were built as close as possible to the old sewers on opposite sides of it, the footing being often cut away to clear them.

The clearance between the top of the sewer and the surface of the street varies from a minimum of 4 ft. to a maximum of about 9 ft. Where it is 5 ft. or more, riveted plate girders with an economical depth of web are used. Type A supports one column with a minimum clearance of 4 in. above the top of the arch. The distance of the columns from the nearest abutment varies from about 8½ to 14 ft. and the corresponding maximum pier reactions are 226,000 lb. and 177,000 lb. Two duplicate girders 18 in. apart on centers are used, each having a 42 x ⅜-in. web and two 6 x 6 x ¾-in. angles and one 13-in. cover plate in each angle. In three cases where the clearance above the sewer is very small a single column is seated about 2½ ft. from the pier center on a grillage known as type F, which clears the top of the arches by 2 in. and is composed of four 15-in. 80-lb. I-beams. Here the maximum reaction is 214,000 lb. In this case the 16,000-lb. reaction at the other pier is so very small that it was considered that the amount of stress transmitted to the sewer would be inconsiderable and the new pier was allowed to be built on the sewer footing, thus furnishing the only exception to the requirement that the pier and sewer footings should be separate. In two other cases the clearance above the sewer is still less and the grillage is made in one case with two and in the other case with four 15-in. 80-lb. I-beams 12 in. apart on centers.

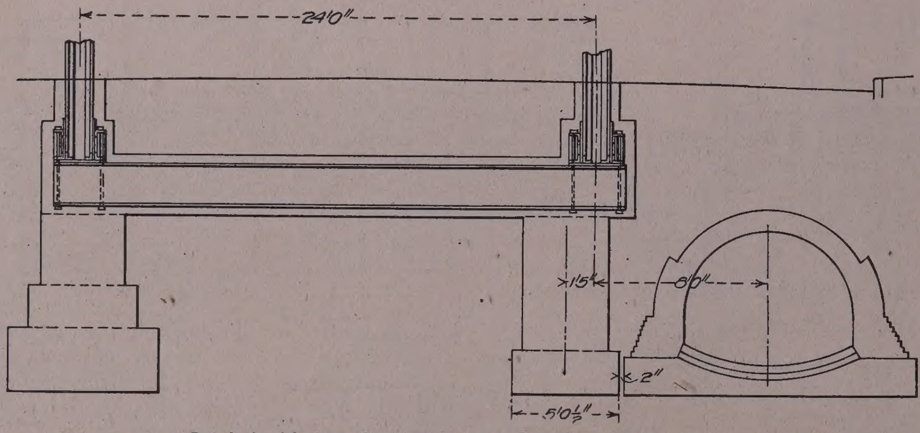
In type B, two columns 29 ft. apart on centers and 5 ft. from the center of the nearest pier are carried on plate girders 4 in. clear of the sewers. The maximum pier reaction is 370,000 lb., and each girder has a 42 x ½-in. web and two 6 x 6 x ⅞-in. flange angles. The minimum pier reaction is 230,000 lb. and the corresponding girders have 28 x ⅝-in. webs and 6 x 6 x ⅞-in. flange angles. In type C the clearance is less and the pair of columns is carried on a set of six 24-in. 80-lb. I-beams with their top flanges at a minimum distance of about 3 ft. below the surface of the street. The minimum distance between centers of columns and adjacent piers is 4.17 ft. and the corresponding maximum pier reaction is 360,000 lb. In type D the clearance above the arch is still less but the girders are maintained at the same minimum distance below street level by providing a recess in the top of the brick sewer arch to receive their lower flanges. This involves cutting only part through the crown of the arch, making a transverse channel filled with asphalt to a depth of 1½ in. to secure thorough waterproofing, and more particularly to avoid actual bearing on the arch. The distance between centers of piers varies from 33 to 36 ft. and the distance between columns and adjacent piers varies from 1 to 3½ ft. The columns are generally arranged symmetrically with maximum pier reactions of 490,000 lb. In type E the clearance is still less than in type B, and the columns are carried on six or eight 24-in. 80-lb. I-beams seated in transverse slots made through the entire thickness of the crown of the sewer arch. Horizontal transverse 6 x 6-in. angles are riveted across the lower flanges of the beams near their intersections with the intrados to receive the thrust of the incomplete arch rings, and the arch masonry where it is cut is thoroughly water-proofed with a 1½-in. layer of asphalt. The distances between the columns and adjacent pier centers varies from 2 to nearly 6 ft. and the maximum pier reaction is 470,000 lb.

Type K is used for seven bents where both columns are on the same side of the sewer and are 24 ft. apart on centers. The nearest one is 8 ft. from the center of the adjacent arch, thus bringing its location 1½ ft. on the sewer side of the pier center. In order to carry it in this position it is supported on the cantilever extension of the girder made with two 24-in. I-beams 30 ft. long supported on piers 22½ ft. apart. In types A and B, where plate girders are used, the width across their top flanges is limited to about 30 in., and no difficulty was found in distributing the column loads across them through the ordinary base plates of the columns, which were therefore seated directly on the girder flanges. In all other cases the width of the grillage is much greater and the load is uniformly distributed across the different units by means of a transverse grillage of three 12-in. 40-lb. I-beams and two 12-in. 20½-lb. channels interposed between the column base and the girder flange. In all cases the columns are anchored to saddle plates across the lower flanges of the girders by means of two vertical 1½-in. screw rods with their upper nuts bearing on the reinforced horizontal flanges of connection angles riveted to the faces of the columns. In all cases the interior of the columns below street surface, and the spaces between the girder webs are filled solid with concrete and all other steel work below the surface of the street is protected with a solid concrete jacket not less than 4 in. in thickness.

The construction of the foundation work requires the excavation of about 200 pits to an average depth of about 20 ft. below the surface of the street; the cutting away of interfering portions of the old sewer footing, the construction of the new concrete piers, the placing of foundation girders and grillages and enclosing them in concrete. This includes the excavation of about 13,000 cu. yd. of material, the placing of about 8,000 cu. yd. of concrete and the handling of about 800 tons of girders. The contractor has installed in the road at the south end of the work a rolling timber platform on which is mounted a 6-ton stiff-leg derrick with a 30-ft. boom and a double-drum, four-spool Lidgerwood hoisting engine and boiler. Adjacent to it is a wooden tower with a measuring hopper which is filled with concrete material delivered to it by a derrick and discharged into a Ransom concrete mixer below, which in turn delivers to 1-yd. steel dump wagons manufactured by Thomas Hill, that are driven a maximum distance of about 400 ft. to deliver the concrete to the different piers. Steam for the hoisting engine, concrete mixer engine, and for three pulsometers is made in a 25 h.-p. boiler and distributed through 2-in. unjacketed mains on the surface of the ground along the line as required. One eight-man gang lays out the piers and excavates them to a depth of about 8 ft., as deep as the earth can be conveniently shoveled out, and lines them with the first tier of 2 x 10-in. square edge sheet piles driven by hand as the excavation progresses. They are followed by a second gang of about eight men who install pulsometers for draining and well digger derricks with 15-ft. booms of about 2,000 lb. capacity and stiff legs conveniently ballasted with short sections of I-beams. They are provided with hand windlasses by which the half-yard tubs of earth are elevated. A third gang of sixteen men dig open trenches from both pits to the outer edges of the double track of the electric car lines 11 ft. apart on centers, the traffic being in meantime restricted to the car tracks and the space between them. They make shallow excavations between the rails and between the tracks and in them lay transverse wooden beams supported on the lower flanges of the 10-in. girder rails. These are covered with longitudinal wooden deck planks 4 in. thick with their upper surfaces flush with the tops of the rails. Under the deck thus formed about 3 to 8 ft. long parallel to the tracks, the excavation is continued by tunneling between the two open trenches and the rails are supported as fast as undermined by blocking and vertical shores built up from the bottom of the trench.



Storage Room and Water Tanks on Roof of Laundry Building.



Buried Girder for Elevated Railroad Foundation.

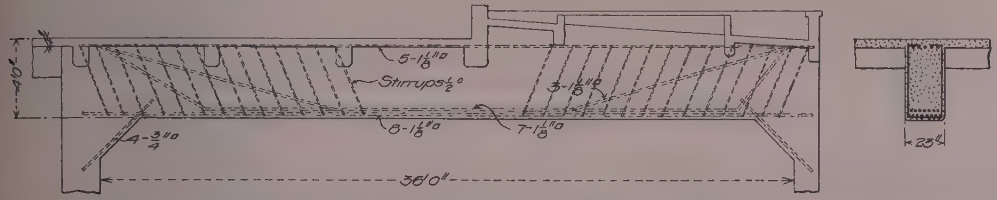
The lower parts of the piers are somewhat irregular in size and dimensions and, if on rock, simply consist of 1:3:6 concrete footings filling the entire bottom of the pit and deposited without inside forms. The contractor usually prefers to carry the concrete for this lower course to the sheeting in order to save the time and cost of placing a form for it. As they extend to an average depth of 12 ft. below high tide, there is considerable seepage of water through the sand and mud besides the large flow which follows from the river along the sides of the sewer tunnel and requires considerable pumping with a steam syphon. In order to handle it more conveniently a temporary bulkhead is often placed across the center of the bottom part of the pit leaving one side to act as a sump while concrete is filled in the other side, after which the syphon is removed and the second half is also filled with concrete. On top of this footing the first course of the offset piers is built about 5 ft. high in a 5 x 8-ft. form. The width of the pier is nearly constant, but the length varies with its depth and the character of the bottom of the pit. The other two courses of the pier are built in the same manner with 1:3:6 Grant Portland cement. When the piers are not carried down to solid rock, their concrete is made 1:2½:5. After the piers have sufficiently set, the girders are inserted in the tunnels under the tracks and are filled and inclosed with concrete and the grillages are placed on them to receive the columns. In order to make a sort of flashing between the concrete on the girders and that surrounding the column bases inside and outside forms enclosing the columns with a space of 3 in. between them are used, forming an extension of the concrete integral with the girder protection as shown in the details and bonding this concrete with that which later on is set around the column base or grillage.

The work is designed and the structure is supervised by the New York Rapid Transit Railroad Commissioners, Mr. Geo. S. Rice, chief engineer, Mr. Alfred Craven, deputy chief engineer, Mr. Sverre Dahm, general inspector of designs, Mr. C. V. V. Powers, division engineer, and Mr. H. J. Howe, assistant engineer in charge. Mr. T. P. Kinsley is the contractor for the foundation work.

Coalite is the name given to fuel now attracting considerable attention in London. It is the result of a partial distillation of coal which leaves behind a residue containing a considerable percentage of volatile matter, and is of a black color and very friable. The secret of preparing the fuel lies in the method of compacting it into a hard substance which can be burned like coal or coke. Coalite has been tested by a number of prominent British engineers and their testimony is practically unanimous that, although it contains a smaller number of thermal units per pound than bituminous coal, nevertheless a much larger percentage of its heating value is useful so that it takes at least 50 per cent. more coal to make a fire equal to that produced with coalite. The commercial feature of the new fuel depends very largely, of course, on whether the by-products, such as gas and tar, which result from the partial distillation of the coal can be sold readily and whether the coalite can be marketed at a price which will make it attractive. At present very little information seems to be available concerning these essential aspects of the new fuel.

A Reinforced Concrete Laundry Building.

The 100x155-ft., three-story, reinforced concrete building, on the southeast corner of Oakland and Laidlaw Avenues, Newark, N. J., occupied by the R. H. H. Steel Laundry, was erected in the short time of sixty-three working days. It was built to take the place of a three-story frame building, formerly occupied by the laundry on the same site, which was burned down April 2, 1906. After the fire temporary quarters were secured in a neighboring building and a gas engine was installed to run the necessary machines. The boiler in the old plant was in such condition that it could be used to provide steam for various purposes in the temporary plant. Accordingly, on May 3, a contract was awarded for a reinforced concrete structure, to be built without interfering with the use of the old boiler. The first story contains the power equipment, wash room, offices and driveway and is 15-ft. high from floor to floor. The mangle room occupies the entire second story, which is 13 ft. high. The third story is 12 ft. high at the eaves and contains the domestic laundry department. The latter, however, represents only a small part of the business, which is mainly steamship and railroad work.



Reinforcement of the 36-Ft. Driveway Girders.

Four 36-Ft. Girders Supporting Two Stories over Driveway.

Each floor is five bays wide and seven bays long, except the first, which has a 16-ft. extension in the rear for a driveway. The usual spacing of the columns is 19 ft. 9 in. each way. The columns are 19⅛, 15¼ and 9 in. square in the first, second and third stories, respectively, except sixteen special columns, each of which supports on its top, 2 ft. above the roof, the corner of a 25,000-gal. reinforced concrete water tank. These columns are 23 in., 19⅛ in. and 15¼ in. square in the first, second and third stories. Every column is reinforced with four vertical Ransome bars which are wound with a ¼-in. round steel rod every 12 in. The vertical bars are the same size in all columns in each story, being 1 in., ¾ in. and ⅝ in. square in the first, second and third stories respectively. The main floor and roof girders extend longitudinally through the building. Between them extend the floor beams, which are spaced 6 ft. 7 in. and divide each bay into three panels. The second and third-floor girders are 14x20 in., the longitudinal reinforcement in each being seven 1-in. square Ransome twisted bars. The floor beams are 9x13 in., and are reinforced with five ⅞-in. bars. The 4-in. concrete floors are designed for a live load of 150 lb. per square foot and the roof for 40 lb. per square foot, with a factor safety of four. A 1-in. finishing coat of cement was applied to the floors in the second and third stories as they were laid.

On the second floor there are nine mangles, each of which occupies a 12x12-ft. area and weighs about 18,000 lb. Six of these machines are placed close together in one longitudinal bay near the center line of the room. In order to secure as much window space as possible, balanced sashes were used in each story. The use of window weights was thus avoided and the width of the mullions is only about 3 in. The concrete used throughout the building, except in the floor of the first story, which is cinder concrete, was a 1:2:4 mixture of Lehigh Portland cement, sand and crushed trap rock. It was prepared by a Foote mixer and delivered to the upper floors and roof with a two-barrow hoist operated by a Lidgerwood engine.

The driveway extending across the rear end of the building has a little over half its width within the building proper, and the remaining half is covered with a lean-to roof, in which are three 10x17-ft. skylights. Four 23x48-in. reinforced concrete girders, with a clear span of 36 ft., support the building and roof, over the driveway. The end wall of the building is carried about 16½ ft. from the outer ends of these girders, each of which has fifteen 1⅛-in. Ransome bars near its lower surface and five similar bars near its upper surface. The arrangement of the reinforcement in these girders, which is shown in an accompanying illustration, is typical of the system which has been used in all the floor and roof girders and beams.

Each of the four water tanks, carried above the roof by the special columns, is 19 ft. square and 10 ft. deep. The walls of each tank rest on 15-24-in. reinforced concrete sills, connecting four column tops. The floor of the tank is supported by four 20x29-in. beams, tied into the sills, two extending in each direction. Each of these is reinforced near its lower surface with fifteen ¾-in. square bars. The inside of the tanks was plastered with a 1-in. coat of 1:1 cement, which was then covered with two coats of R. I. W. waterproofing compound made by Toch Bros., New York. One end of each of the four tanks forms a portion of the wall of a storage room, also built of concrete, the entrance to which is shown in an accompanying illustration.

Mr. Fred A. Phelps was the architect and the building was built by the American Concrete-Steel Co., Newark, N. J., engineers and contractors, for a contract price of $80,000.

Reinforced Concrete Laundry under Contruction.

An Experimental Railroad for testing signaling devices, materials used in track construction and different types of motor cars for railroad use, has been built by the railway department of the German Government. The road is double-tracked and is oval-shaped, having a length of 5,760 ft. The straight stretch is about 800 ft. long.

Driving Concrete Piles below the Battery Tunnel, New York.

The tunnel connecting the subway lines of the Interborough Rapid Transit system in the Boroughs of Manhattan and Brooklyn, crosses from Battery Park, Manhattan, to the foot of Joralemon St., Brooklyn, under the East River with two cast-iron tubes lined with concrete having a clear inside diameter of 15½ ft. They are about 25 ft. apart and 6,550 ft. long, descending from both sides of the river to a maximum depth near the center to about 94 ft. below mean high water. They pass through rock on the New York side of the river, thence through about 600 ft. of very fine sand, about 400 ft. of rock, about 200 ft. of hard stratum and about 600 ft. of fine sand again to their connections with the land section of the tunnel in clay and gravel.

The fine sand through which they pass between the rock and the Brooklyn end is, when confined, so dense and hard that it will support a considerable pressure, and when cut will stand well with vertical faces. Under heavy air pressure in the tunnel construction it remains firm and hard and quite dry. Where the air pressure was much less than the hydrostatic head, or where the sand was much agitated, shaken or otherwise disturbed, it became soft and loose and flowed easily. Its character is such that when undisturbed or properly confined it will stand considerable pressure and is considered acceptable for foundation bearings. A considerable part of the land tunnel in Battery Park rests on the same material and there are buildings in New York also supported on it and imposing much heavier loads on their foundations than can be developed by the tunnel tubes.

The tunnel was driven through it with a heavy hydraulic shield and an air pressure of 20 to 35 lb. per square inch. The cast-iron tubes alone weigh about 8,000 lb. per linear foot, and settled very little when the air pressure in them was maintained nearly equal to the hydrostatic pressures at the invert. When this pressure was relaxed it was noticed that more settlement took place, although it was not considered excessive for tunneling through such material by this method. An everage settlement of about 0.4 ft. was observed immediately after the construction of the tunnel rings, and, except in a few places, where there was excessive leakage, did not increase after the shield was a few days past the point noticed.

It was observed, however, that after the tubes were completed the settlement could at any time be produced by the admission of materials from the exterior of the tunnel through its lower portion. None of these settlements were considered serious enough to require correction of grade or alignment, and the only subsequent precaution considered necessary was to close the principal leaks through the lining before the air pressure was removed, after which the joints could be calked at convenience.

The weight of the completed tube with concrete lining and track is about 11,000 lb. per linear foot, and that of the train 2,000 more, making a maximum total of 13,000 lb. per linear foot, as compared with 14,000 lb. for the volume of water displaced. It was therefore evident that there could be no excessive downward pressure on the sand and that no settlement could take place without an inflow of the material through the bottom of the tunnel tube, or the displacement and lateral movement and upheaval of the material under the tunnel tube and the bed of the river above it, a contingency which is evidently impossible. On the other hand the weight of the tunnel, friction and adhesion of the material penetrated, and the stiffness of the tunnel tube considered as a girder, provide a large factor of safety in the resistance to upward displacement. The engineers and designers therefore consider the safety of the tunnel as eminently satisfactory.

Where the tubes pass through rock and hard strata they are grouted externally to make a very rigid bearing, and as the conditions of support are somewhat different in the fine sand it was suggested that additional provision should be made for possible vibrations and to avoid abrupt change of support. These modifications were not considered necessary or wholly desirable by the engineers, but it was finally decided, in order to afford the greatest possible public reassurance, to permit the construction of auxiliary supports exterior to the tunnel which could be built without materially delaying its opening for traffic. The work was therefore recently undertaken and is being executed simultaneously with the construction of a ventilation chamber which is the only remaining important work on the construction to be completed before the tunnel is put in service.

The new construction is very simple and consists merely of a series of transverse pile bents at irregular intervals of about 50 ft. supporting the undersides of the tubes for two lengths of about 600 ft. each, separated, as previously mentioned, by the rock reef in the middle of the channel. In each bent there are two reinforced concrete piles 20 in. in diameter and about 7 ft. apart on centers. All of the piles are driven to rock or hardpan, and on the Brooklyn side of the channel vary from a very short length near the reef to a maximum of about 50 ft. nearest the Brooklyn shore, where the rock surface slopes downward to an unknown depth, and the piling will probably be discontinued. Between the two rock sections the piles have an average length of about 30 ft.

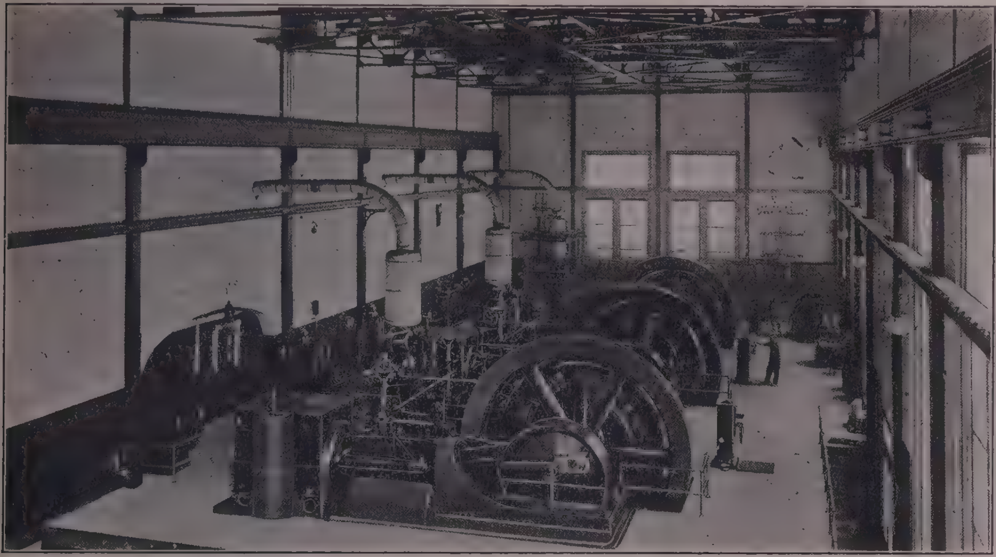
A portion of each tube about 1,000 ft. long, including all that which is to be underpinned, is enclosed with concrete bulkheads having air locks at both ends and is put under air pressure of about 34 lb. per square inch. Wherever a pile bent is to be located the lower segment of one ring of the cast-iron lining is broken with sledges or with a jack and is removed; the meterial is excavated under it and under the two adjacent rings, the three corresponding segments of which are also removed, leaving an opening about 66 in. long in the invert of the tube. The excavation there is then carried down to complete a horizontal transverse trench about 18 in. deep below the middle of the invert and extending across the full width of the tunnel tube. In this trench two slightly tapered vertical cylinders of thin sheet steel 20 in. in diameter, and about 6 ft. long are seated on the center lines of the piles. In each of them there is placed a concentric 4-in. light wrought-iron pipe of the full length and around it there are placed four 1-in. square steel reinforcement rods with their lower ends projecting a few inches below the bottom of the cylinder and converging there to make a sort of pilot. The upper ends project slightly above the top of the cylinder and the latter is filled with 1:3:4 concrete made with Giant Portland cement. After the concrete has set sufficiently a jet pipe with a flexible connection and a 1¼-in. nozzle is inserted in the 4-in. pipe and rapidly scours out the sand so that the cylinder sinks sometimes under its own weight and sometimes by the aid of a 30-ton Watson-Stillman hydraulic jack, reacting against blocking which distributes the pressure against the crown segments of the tunnel tube. When the pile section thus formed is sunk to the bottom of the trench a second is built on it with a cylinder telescoped into the upper end of the first cylinder with an overlapping joint of 2 or 3 in. secured by small bolts or pins; reinforcement bars are put in it engaging the concrete in the lower section and it is filled with concrete. After the concreting has sufficiently set, jacking and jetting are resumed and the combined sections are sunk until the upper one reaches the bottom of the trench when another is added. This is continued until the pile encounters a hard stratum. Two sets of jacks and jets are provided so that both piles of one bent may be sunk simultaneously and two or more bents are under simultaneous construction so that one may be sunk while the concrete is setting in another.

After the piles are completed the trench is filled with concrete making a transverse wall which forms a connecting cap for them and serves as a cradle with a concave upper surface bearing against the exterior of the cast-iron tube and acting as a cradle for it. The upper surface of the concrete is reinforced with three 1-in. square circumferential rods, and the invert segments are replaced and thoroughly bedded in it. Before the concrete cradle is built the jet holes in the piles are filled with grout under a pressure of about 80 lb. per square inch, which is forced in until a considerable quantity escapes from the lower end, where it is expected that it will improve the bearing of the pile on the rock or hard sand. The work is being carried on continuously in three 8-hr. shifts, and the piles have been driven at the rate of as many as three pairs in a week, a record which will probably be considerably improved as the speed is continually increasing with the additional experience and familiarity gained. The hydraulic jacks are operated by a pump driven by compressed air, and the hydraulic jet is furnished by a Cameron pump also driven by compressed air. The work is being executed by the New York Tunnel Co., under the direction of the engineering staff of the Rapid Transit Subway Construction Co.

WEED DESTRUCTION on many of the Western railways is an important problem. The lines which have light traffic are ballasted with dirt and the weeds grow rapidly to such a height that the movement of trains is materially retarded and the cost of operation consequently increased. Different plans for getting rid of this vegetation have been tried, but until recently the customary method was to keep gangs of men at work during the whole season cutting it down. Sprinkling the roadbed with salt and oil has not been considered successful on most of the roads which have tried it, and several attempts to burn the weeds have not been continued, indicating that for some reason this method was unsatisfactory. The Union Pacific Ry., however, has a burning car which has made a good record. It is a four-wheel car fitted with a gasoline engine which can drive the car at a speed of three to four miles per hour while burning weeds, or 12 to 15 miles while going to and from work. The engine also drives an air compressor which keeps a number of large tanks containing gasoline under pressure. At the back of the car there are three large inverted pans, somewhat similar to those used in many cities for heating asphalt before it is removed from paved surfaces. These three pans have gasoline jets below them so arranged that a mass of flame can be directed upon the road-bed for a width of 12 ft. The car will burn the weeds over a strip of 20 to 25 miles length in a working day, and is run under orders like a regular train. The best results have been obtained by burning down the growth when it has reached a height of 6 to 8 in. and then going over it again a few days later. This kills over the roots and leaves the road-bed free from vegetation, which is not the case when the weeds are cut down by a gang of men, for the roots are then left ready for development at once. The machine is said to go over the track at a cost of about $5.75 a mile, which is about one-quarter of the cost for a section gang.

New Power Plant of the Central Pennsylvania Traction Co. at Harrisburg, Pa.

The Central Pennsylvania Traction Co., which operate 64 miles of city and interurban electric railway lines in Harrisburg, Steelton, Middletown, Penbrook, Hummelstown, Highspire and Oberlin, has recently completed a power plant of approximately 2,000 kw. capacity in Harrisburg, to supply an increased demand for power. The new plant is adjacent to the company's old No. 1 power station on South Cameron St., about 1¼ miles from the center of power consumption.



Interior of Engine Room, Showing Opening into Pump Room.

Other sites were considered, two of which were better located with reference to power consumption and condensing water supply from the Susquehanna River, but neither could be obtained. It was finally decided to locate the plant on the present site and build a condensing and boiler water tunnel about 1,100 ft. long to the Susquehanna River.

The power house is approximately 175 x 103 ft., with a steel skeleton and concrete curtain walls, the columns being designed simply to carry the crane and roof loads; only sufficient lateral bracing in the shape of diagonal rods was used to maintain the framework in position while filling in the walls. The walls are of mass concrete, generally 12 in. thick, and were carried up by filling in plain forms in sections about 3 ft. deep, the forms being secured to and held in alignment by the columns.

The building is divided longitudinally into two rooms of nearly equal size, the front portion being occupied by the generators, engines and switchboard and the rear by the boiler equipment. The engine room floor is about 8 ft. above the street level and 5 ft. above that of the boiler room and there are basements under both divisions, that under the engine room with 9½ ft. headroom, and under the boiler-room 10½ ft. headroom. At the rear of the boiler-room there is an elevated platform, 25 x 30 ft. in size, 17 ft. above floor level, which carries the economizer and main smoke flue, the latter occupying the center of the platform and the present economizer installation adjacent to the boilers. The space underneath is enclosed for a pumproom which opens out into the engine-room, and contains the feed pumps, feed heaters, condensers, circulating water and air pumps. Only a little more than half the floor area of the building is occupied by the present equipment, but the rapid increase in the power requirements of the traction company in the past few years indicated the advisability of providing ample space for future growth.

New Power Station of the Central Pennsylvania Traction Co.

The foundations for the building consist of continuous concrete walls 5 to 8 ft. deep, with a stepped footing 6 to 8 ft. wide at the bottom, which is not reinforced. The site is made up mostly of top clay filling from an old quarry, the street grade being about 20 ft. above rock. This fill is in irregular strata of clay and wet loamy soil with gave an irregular and more or less uncertain bearing value. The foundations as placed were designed for a maximum bearing on the subsoil of 3,000 lb. per square foot. When excavating for the rear wall foundations, however, the subsoil was found so completely saturated with water as to be considered unsafe with the above described foundation, and piers were carried down to within 4 or 5 ft. of rock, where a stratum of hard, dry, gravelly clay was found, the footing being afterwards put in on top of these piers. The foundations for the interior columns supporting the coal bunkers and economizer floor were also carried to the lower stratum of clay. The situation was considered ideal for the use of concrete piles and the designer would have preferred this method; but found on investigation that more time would have been required to place these piles than was available. The results have been altogether satisfactory and there has been practically no settlement.

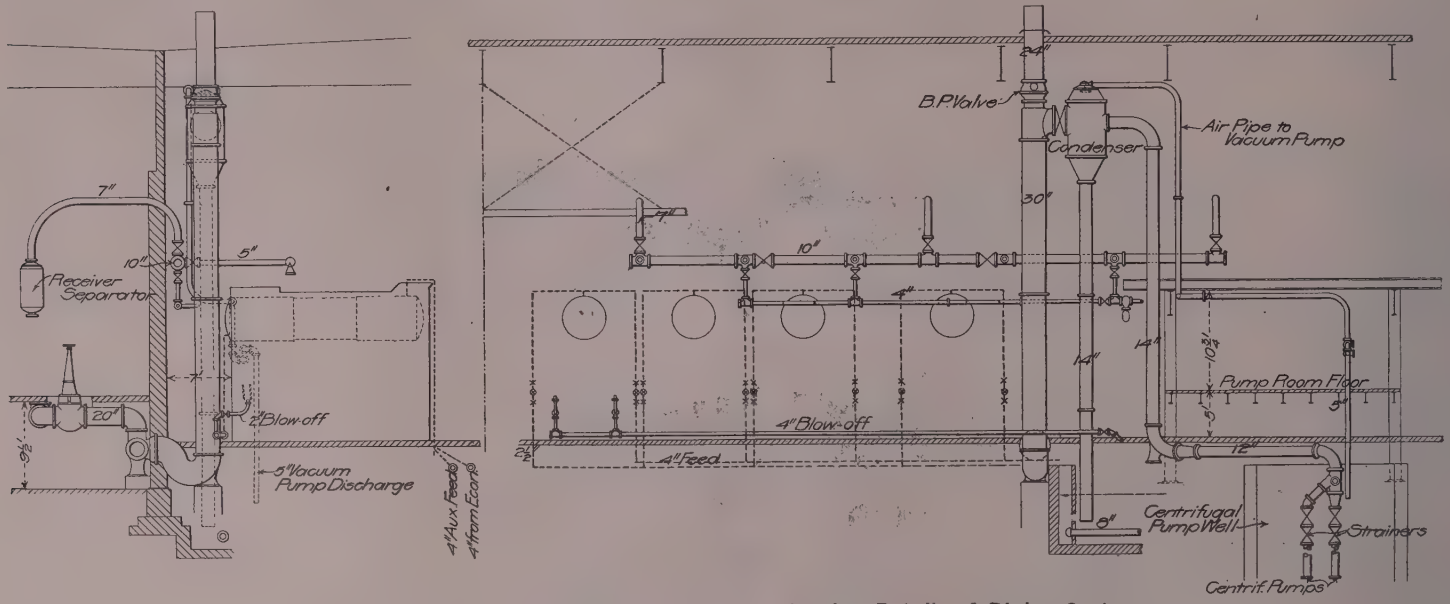
The front of the building is of mass concrete with a face of mortar mixed fairly dry and placed in the forms and back-filled with rough concrete. The windows in the front opening into the engine-room measure 10 ft. wide by 23 ft. high. There are two swinging sashes on vertical pivots and one large transom, all being filled with plate glass. The windows extend nearly to the floor line. The roof consists of 8-in. channel purlins placed about 6 ft. between centers and covered with 3-in. cinder concrete reinforced with ⅜-in. round rods and this in turn covered with four-ply tar paper and slag roofing.

Clearfield coal is delivered to the building over a siding from the Pennsylvania R. R. between the rear wall and the chimney. Near the center of the building and under the track is a hopper which receives the coal as it is dumped from the cars. The coal passes to a crusher and thence to the boot of a vertical bucket elevator. This latter delivers the coal to a screw conveyor in the roof of the building from which it is distributed to a rectangular coal bin having a capacity of 600 tons, which extends the full length of the space occupied by the boilers. It has a steel frame supporting a concrete lining. A gate is placed directly in front of each boiler and the coal is delivered to the boiler-room floor by a traveling weighing hopper.

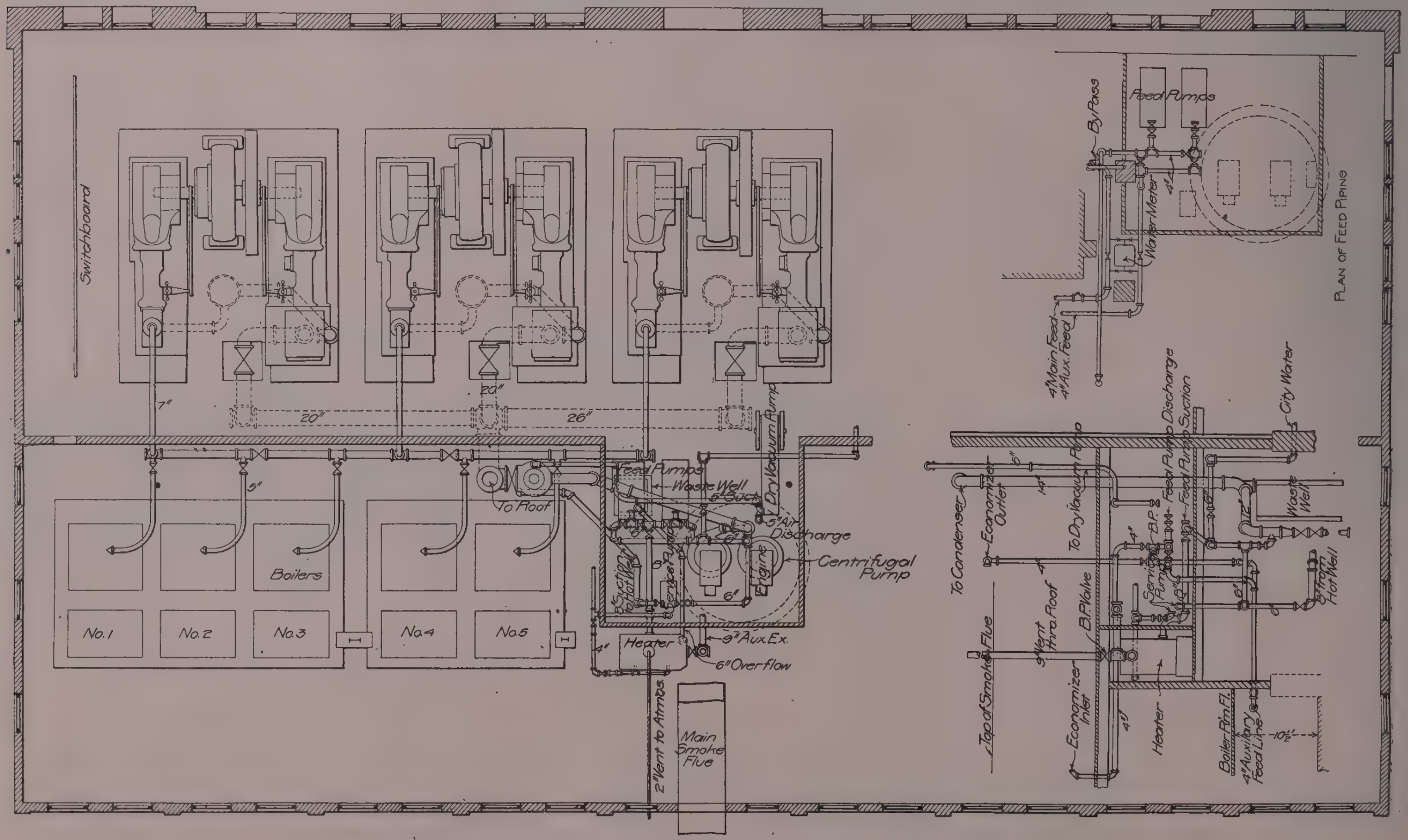
Ashes drop from the hand-fired shaking grates into pits from which they are removed in a steel dump car and delivered to the elevator boot mentioned. They are then elevated to a bin in the roof having a capacity of about one car load. The proximity of the elevator to the bin obviates the necessity of handling the ashes by the screw conveyor, and they are discharged outside of the building by a gate and chute. By this arrangement, the car on the track outside may be emptied of its coal and filled with ashes without being moved. The coal and ash handling machinery has a capacity of 20 tons per hour and was furnished by the Jeffrey Manufacturing Co., Columbus, Ohio.

The chimney is a reinforced concrete stack, constructed by the Weber Steel Concrete Chimney Co., of Chicago, and is 23 ft. to the rear of the building. It has an internal diameter of 10 ft. and is 190 ft. high above the boiler-room floor and 215 ft. above the foundation. The chimney stands on a circular base 25 ft. in diameter and about 3 ft. thick, and for 75 ft. of its height above the boiler-room level has two shells, an inner shell of 4 in., a 4-in. air space and an outer shell of 7 in. The upper 115 ft. has a single ring 5 in. thick, and the chimney is reinforced throughout with 1¼x1¼-in. tees, vertically, and ¾-in. round rods, horizontally.

The main flue opening is 7½ x 12½ ft., the bottom of the opening being 18 ft. above ground, and to this the main flue passes directly from the elevated platform over the pumproom.



Part Transverse and Longitudinal Sections, Showing Details of Piping System.



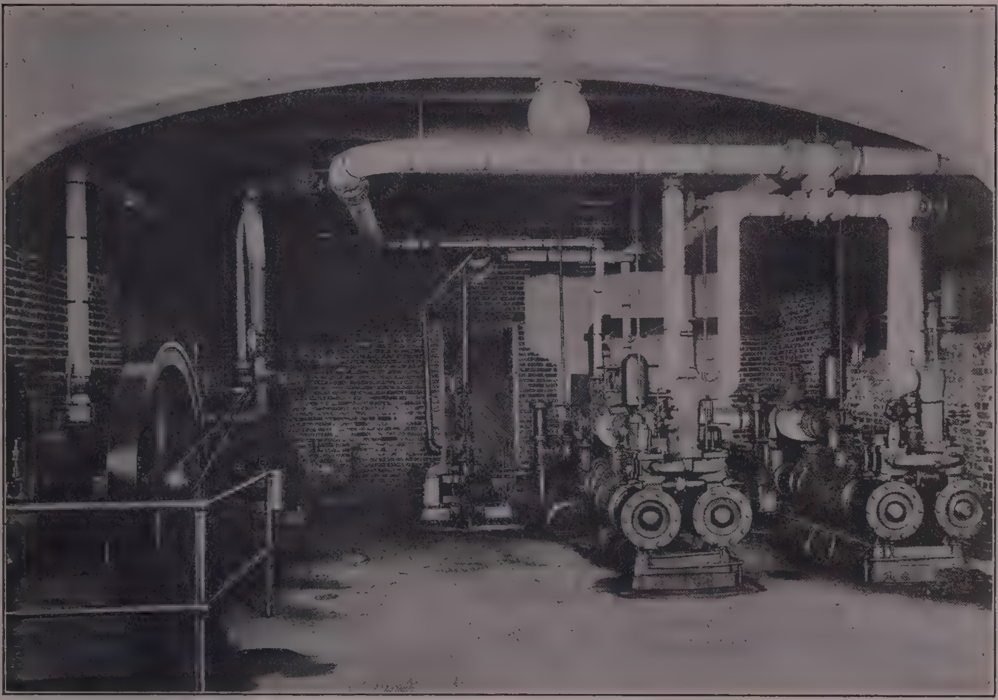
Plan of Harrisburg Power Station, Showing Details of Piping System.

The station now has five 327-h.-p. water-tube boilers, built by the E. Keeler Co., Williamsport, Pa., which are set in two batteries of two and three units. They are of the single-drum type with 164 inclined 4-in. wrought-iron tubes 18 ft. in length. The drum is 54 in. in diameter by 22 ft. long, and to either end is attached the tube headers or water legs into which the tubes are expanded. The boilers are designed for operation with 175-lb. steam pressure, and are fitted with Foster superheaters, built by the Power Specialty Co., New York, designed to raise the temperature of the steam 100° Fahr. above that of saturation. The furnaces are fitted with Regan shaking grates, with areas of 6 x 9½ ft. each.

It is the intention to secure all water for boiler and condenser purposes from the Susquehanna River by driving a tunnel about 5 ft. high and 6 ft. wide through limestone 40 ft. below the surface of the ground. The tunnel starts from a shaft 15 ft. in diameter directly under the pumproom and passes out under the center of the chimney, most of the tunnel being under the yard of the Central Iron & Steel Co., which latter concern is interested with the traction company in the execution of the work, as it intends to utilize the same source of water supply later on. From the bank where the terminal shaft is placed, there extends out into the river about 700 ft., a 36-in. wood stave pipe placed in a trench cut in the rock bottom of the river. The construction of this tunnel and intake is now well under way and the capacity of it will be about 15,000,000 to 20,000,000 gal. daily.

The steam piping for the plant was installed by the Best Manufacturing Co., of Pittsburg, and is designed throughout for a pressure of 200 lb. A 10-in. boiler-room header receives the steam from the five boilers through 5-in. branches, and from this lead 7-in. long-radius bends through the wall to each main engine immediately above the high pressure cylinder. Above the throttle of each engine there is located a Cochrane separator which also acts as a steam reservoir. A 4-in. auxiliary main runs a few feet below the main header from which connections are taken for the auxiliary pumps. This main also serves as a drain for the main header. The exhaust steam from the three main engines is gathered in a 20-in. exhaust main of straight riveted pipe in the engine-room basement, and thence passed through an Alberger condenser, while that from the auxiliaries is passed to a Cochrane open heater. Feed water is ordinarily taken from the hot well to the open heater from which the boiler feed-water pumps deliver it to the Green economizer and thence to the boilers where it arrives normally at a temperature of approximately 300°.

The condenser is a 30-in. jet type barometric built by the Alberger Condenser Co. The water is delivered to the condenser by vertical-shaft centrifugal pumps in duplicate, each of which has a capacity of 1,000 gal. per minute. This type was adopted on account of the fluctuation in the height of the Susquehanna River. The pump floor is 33 ft. above extreme low water. As the river has a maximum rise of 27 ft., and it was desired to have all moving machinery under the direct control of the engineer, besides easy of access, the layout was arranged accordingly. The centrifugal pumps and the driving engines were furnished by the Morris Machine Works. The boiler feed pumps are Worthington 12x7x10-in. duplex pumps.


View of Pump Room from Engine Room.

The three main engines were furnished by the Allis-Chalmers Co. They are of the horizontal, cross-compound, rolling mill type with cylinders 22 x 48 x 42 in. Each is provided with double eccentrics and butterfly automatic stop valves. The engines have a guaranteed rating on 165 lb. steam pressure, with 75° superheat, of 984 i. h. p., with a steam consumption of not over 12.4 lb., the speed being 100 r. p. m. and the vacuum reading 26 in. Without superheated steam, the steam consumption is guaranteed at 13¼ lb. per horsepower-hour.

The generators are of the Bullock railway type having ratings of 600 volts and 1,084 amperes and guaranteed to run 24 hours under full load without sparking and without rise in temperature of more than 40° above the temperature of the surrounding atmosphere. They are also guaranteed to carry an overload of 50 per cent. following a 24-hour run for one hour, without heating the windings more than 55° Cent., and to carry a momentary overload of 100 per cent. The guaranteed efficiency of the generators at three-quarter load is 93.8 per cent., and at full load, 94.2 per cent.

The switchboard was built by the Westinghouse Electric & Manufacturing Co. It has four generator panels, of which one is blank; three storage battery panels; one total load panel; eleven unboosted feeder panels; four boosted feeder panels, two booster panels and one blank panel. No boosters have as yet been installed. Each generator panel is equipped with a circuit breaker, indicating ammeter, quick-break switch and Thomson watt-hour meter, together with voltmeter plugs and receptacles for the voltmeters on the swinging brackets at the end of the board, besides the usual field rheostat, the resistance for which is placed below the floor. The three storage battery panels were furnished by the Electric Storage Battery Co. The panels are provided with the usual controlling devices, including a carbon regulator. The storage battery is installed in a building immediately adjoining the power house and is made up of 288 cells. The total load panel is equipped with an indicating ammater, a recording ammeter and a recording voltmeter. Each of the feeder panels is equipped with a single-pole, quick-break switch, a circuit breaker, an indicating ammeter and a watt-hour meter. This makes a very complete feeder panel, as it is not the usual practice for railway companies to place a watt-hour meter on each feeder.

The total cost of the station, exclusive of the intake tunnel, is about $230,000. Excavations for foundations were begun early in January last year, and power was furnished on the line late in May. The station took the entire load and three old stations were abandoned in October. Owing to the large increase in the number of cars operated and alterations in schedules, the station is furnishing an average of 60 per cent. more power than was required to operate the system a year ago. The entire plant was designed and constructed under the direct supervision of Mr. Mason D. Pratt, of Harrisburg. Associated with Mr. Pratt were Messrs. C. O. Mailloux and W. C. Gotshall, of New York City, acting as advisory engineers.

The Steelwork Erection of the Baltimore & Ohio office building, which was described in The Engineering Record of June 1, 1907, was done by Wells Bros. Co., of New York, instead of by the American Bridge Co., as stated. The latter company, however, supplied the steel.

The Isthmian Canal.—A General Resume of the Work Accomplished.

A paper read before the St. Louis Railway Club by Mr. F. B. Maltby, Principal Assistant Engineer, Isthmian Canal Commission.

So much has been written under the caption "The Truth Concerning Panama" that the writer was somewhat at a loss for a subject when asked by your secretary to prepare a paper on Isthmian Canal construction. For the past two years or more there has scarcely been a month that some one or more of the popular or technical magazines has not contained an article on the Panama Canal, and at times there has been a deluge of this sort of literature. The writer, during a stay of over two years on the Isthmus, has had the pleasure of meeting many of the authors of these articles and he believes that most of them were actuated by a sincere desire to report the conditions truthfully as they saw them, and if they failed, it was largely due to the fact that they attempted to cover the subject after a stay on the Isthmus of from one to two weeks, while a few of them have even covered the whole in as many days. The subject is a large one, and the writer does not attempt to cover it. You are all familiar with the "horrible conditions" as depicted by our yellow journals—the mismanagement, the graft, the mistakes due to incompetent officials, etc., and it is not necessary to dwell on these features.

Railway men are essentially business men, and business men are interested usually in results—what have you done—rather than excuses or explanations. I have thought, therefore, that for railroad men a brief and general résumé of the work accomplished under the direction of that most successful and well-known railroad man, John F. Stevens, will be of interest.

In calling attention to the work done under Mr. Stevens' administration, the writer especially wishes to deny any desire to criticise or reflect in any way on the capabilities of either his predecessor or successors. Mr. Wallace was not in any way at fault or responsible for the conditions existing except possibly the feeling of unrest and insecurity among the employes caused by a change in administration. He was certainly not responsible for the deplorable condition of the Panama Railroad, its lack of terminals and rolling stock, the shortage of material of all kinds, and the fact that it takes time to procure track material and men to lay it; steam shovels and dredges, and men to operate them. In fact, immense quantities of material and equipment had been ordered by the former chief engineer that was put into the work under the direction of Mr. Stevens.

In considering the work of construction performed it is naturally divided under the headings, Panama Railroad, Excavation of Culebra Cut, Dredging, Construction of Locks and Dams, Municipal Construction, Building Construction, work in the Mechanical Department and the branch of Labor and Quarters.

The Panama Railroad is operated under a separate and distinct corporation, the United States owning practically all the stock. The interests of the canal and the railroad and their physical connections are so interdependent that they must be considered together. In fact, the construction of the canal without a railroad would be impracticable, and it should be considered as one of the tools for construction.

The railroad could hardly have been in a worse condition than when the Americans assumed charge. It consisted practically of a fairly good roadbed with light and worn rails, antiquated and worn-out equipment, limited in size and quantity, with methods of operation as antiquated as the equipment.

The following is a quotation from a report made by Mr. Stevens: "About the only claim for good work heard made was that there had been no collision for some time. A collision has its good points as well as its bad ones—it indicates there is something moving on the railroad." The purchase of new rails, new locomotives, cars and other equipment had already been ordered by the old commission. These have been received, set up and facilities enlarged. The organization and methods have been changed and improved till at present it would be difficult to find a railroad handled under more modern up-to-date methods than the Panama Railroad.

At Cristobal, the Atlantic terminus, two docks having a total length of over 2,000 ft. with an available depth of not less than 26 ft., have been constructed. A modern coal-handling plant for unloading coal from colliers onto cars, and a modern cantilever crane having a travel of 350 by 700 ft., for handling bulky cargo have been installed.

At La Boca, the Pacific terminus, the dock facilities have been greatly enlarged. Entirely new shops, engine houses and a modern terminal switching yard have been built at Cristobal, and additional station buildings and switches added all along the line.

About twenty-seven miles of double track has been laid and put into operation. It is possible that over a portion of the line a third and fourth track may be reuqired. To give in detail all the work done on the Panama Railroad would add too great a mass of figures to a paper of this nature. In general, it can be said that commercial business or through business has increased and is steadily increasing. The business in direct connection with the construction of the canal has increased enormously.

The Panama Railroad has built and put into operation at Cristobal in connection with their commissaries, and for supplying the needs of the employes of the Panama Railroad and the commission, a modern plant consisting of a bakery, having a capacity of 20,000 loaves of bread per day; a laundry having a capacity of 10,000 pieces per week, and a most elaborate cold storage plant, having a capacity of about 50 tons of ice and 75 tons of refrigeration per day.

Panama Railroad.—The distance from Colon to Panama is only 47½ miles, and in this distance there is on the Panama Railroad and in connection with the canal construction, about 269 miles of running track and 160 miles of sidings—or in other words, the whole railroad is simply one big yard.

About three and a quarter million dollars have been spent for new tracks, terminals, wharves, bridges and buildings, not including equipment.

Culebra Cut.—The spectacular work now being done on the Isthmus, and the feature that interests the canal visitor the most, is the excavation in Culebra Cut. The greatest amount of work done so far by the Americans in the actual construction of the canal is the excavation between Bas Obispo and Pedro Miguel, known as the Culebra Division.

There are several reasons why the greatest efforts have been concentrated on this division. Under the original French plans, which contemplated a sea level canal, Culebra Cut was by far the largest part of the work to be done. After the failure of the Old French Company, and during the time of the New French Canal Company, the only work performed on the canal was by a small force in Culebra Cut. When the canal property was turned over to the United States Government, work on a small scale was in progress on this division, and it was quite natural that it should be continued and the force enlarged. Practically the only equipment in condition for immediate use was that in the cut, and the first new equipment ordered was to augment that already in use. Furthermore, the excavation of Culebra Cut was necessary whatever type of canal might finally be decided on. In consequence, the organization and equipment on this division are about complete, and there only remains the actual excavation. The accompanying tables show in detail the amount of work done during the last twenty-one months:

Record of Track Work, Excavation and Rainfall.

Date.	Track Laid, Renewed and Restored.	Excavation.	Rainfall.
July, 1905	7000 ft.	78570 cu. yd.	6.42 in.
August, 1905	9520	49210	11.38
September, 1905	46152	41885	6.54
October, 1905	27337	52940	17.99
November, 1905	17319	60540	5.21
December, 1905	16552	70630	4.68
January, 1906	16175	120990	1.28
February, 1906	28535	168410	.57
March, 1906	26273	239178	.45
April, 1906	30816	213177	11.42
May, 1906	29875	194645	7.54
June, 1906	30155	207760	6.92
July, 1906	19531	157093	14.61
August, 1906	16908	244824	11.84
September, 1906	20513	291452	7.41
October, 1906	18974	325835	5.76
November, 1906	18432	221642	21.05
December, 1906	27156	278197	8.11
January, 1907	61880	566750	.08
February, 1907	58117	639112	.13
March, 1907	51214	815270	.16
Total	577434	5038110	149.37

Steam Shovels and Work Trains in Use.

Date.	Number of steam shovels on Isthmus.	Number of dirt trains in service.
July 1, 1905	11	16
January 1, 1906	15	80
July 1, 1906	39	96
January 1, 1907	61	145
April 1, 1907	63	265

Force at Work on Culebra Division at Various Dates.

Date	Gold Employes (Americans)	Skilled Labor (Alien)	Common Labor	Total
July 1, 1905	426	175	1504	2105
January 1, 1906.	438	126	1356	1920
July 1, 1906	578	685	2707	3970
January 1, 1907.	778	569	2918	4265
April 1, 1907	971	1257	4578	6806

Drilling Accomplished by Months, Expressed in Lineal Feet.

Date	Churn or Well Drills.	By Steam or Air Drills.	Hand Drilling.
July, 1905		925	8378
August, 1905		1328	4269
September, 1905		2618	5528
October, 1905		2918	7591
November, 1905		5800	5032
December, 1905	1065	6867	5216
January, 1906	2757	10271	1915
February, 1906	3500	14251	4000
March, 1906	9874	22149	12886
April, 1906	10233	24658	11322
May, 1906	10764	35820	17006
June, 1906	12848	32141	13768
July, 1906	10538	27175	11073
August, 1906	9546	31881	7806
September, 1906	10311	25160	8375
October, 1906	8179	28399	6186
November, 1906	6521	22985	4474
December, 1906	6768	25567	4915
January, 1907	11492	34700	11007
February, 1907	11957	33073	9256
March, 1907	14904	46703	10994
Total	141257	430389	170997

Grand total of 742,643 feet, or 140.65 miles.

In explanation of these tables:

The number of feet of track laid includes new track laid with 70-lb. rail, track laid with old Belgian and Panama railroad rails and all tracks renewed or restored.

The yardage is measured in place before excavation.

The number of dirt trains in service represents the total number of train movements from a shovel to the dumps, counting each trip made as one train, or in other words, on April 1, 1907, 265 train loads were hauled from the shovels to the dumps.

From the best information that can be obtained from our cross-sections, the French Companies excavated a total of about 18,000,000 yards from this division, and this amount of course includes the top and cheapest portion, and with short haul. It will be seen, therefore, that during the 21 months of Mr. Stevens' administration nearly one-third as much was removed as was taken out during the 22 or 23 years covered by the French administration.

Dredging.—The French Company had dredged a channel from the Atlantic terminus nearly to Bohio to a depth of from 14 to 27 feet. Practically no work had been done on this portion of the canal since 1889, and consequently portions of the channel had been partially filled up. It was desirable that the sea end of the canal at Cristobal be deepened and made available for harbor and terminal purposes at the earliest practicable moment, and one of the old French dredges of the ladder type was overhauled and put into commission pending the time that a modern plant could be secured. Work was started in June, 1905, and has been continued since. There is now a harbor at Cristobal over a mile in length and of ample width with an available depth of 25 ft. The old channel above the harbor is being reproduced for construction purposes, though it will not form a part of the canal when completed. On the Pacific side the Panama Railroad Co. was operating one of the old French dredges in maintaining a channel leading to the pier at La Boca. This dredge was taken over by the commission in June, 1905, and has continued in operation since. The shoaling of the channel at La Boca is very rapid, and it has only been kept open by constant dredging. The channel entrance to the new canal will have a different direction to the old one, and it is hoped that the filling in will be much less than in the old one. About one and one-half million yards of dredging has been done at the Atlantic end and two and one-quarter million yards at the Pacific end, or a total of three and three-fourths million yards. This dredging has been done at a cost of between nine and ten cents per yard for operation and repairs. A modern up-to-date dredging plant for doing the work in the new canal has been designed, and is under construction. Contracts now in force cover two large sea-going dredges with a capacity of 10,000 yards of sand per day each; three dipper dredges equipped with five-yard dippers and capable of dredging to a depth of 40 ft. and two hydraulic pipe line dredges, each with a capacity of 10,000 yards per day.

Locks and Dams.—The Act of Congress finally determining the type of canal to be built was not passed and approved till the 29th of June, 1906, and in consequence the actual amount of construction done on the locks and dams is very small. A brief description of these structures is given. At Gatun, about seven miles from the Atlantic terminus, it is proposed to build an earthen dam across the valley of the Chagres River which will hold the water in the lake above it to an elevation of 85 ft. above sea level. The section of the dam, from an engineering point of view, is absurdly large. It is 135 ft. high, or 50 ft. above the water line, and has a breadth on top of 100 ft. and on the bottom of over one-half mile. It will, in fact, be an artificial hill. The locks for passing from sea level into the Gatun lake are also at Gatun and will be in duplicate, and have three lifts of 28⅓ ft. each, or six chambers in all; each chamber will have clear or available dimensions as follows: length, 1,000 ft.; width, 100 ft.; depth over the sills of 41⅓ ft. in fresh water and 40 ft. in sea water. The material forming the foundation for the Gatun locks and dam has been the subject of much criticism and discussion. The writer has been in charge of the investigations of these foundations from the start, and feels that he knows the material thoroughly. On the hill in which the lock will be located, 131 bore holes, having a total depth of 10,800 ft., were sunk—many of these holes extend 60 ft. below sea level, and all well below the bottom of the proposed walls. In addition to these holes, five test pits about 6x8 feet, and distributed over the locks, have been sunk well below the bottom of the walls. I recently had the pleasure of lowering the Hon. Secretary of War into one of these pits about 70 ft. deep for the purpose of examining the material. Much to my relief, the rope held.

The material is a firm soft sand rock—not a rock which one would choose for a building material, but amply firm and strong for foundations. I recently loaded some of it in place, where exposed, with rails to 535 lb. per square inch without a particle of settling. The only reason for not loading heavier was the scarcity of rails. Small samples have been loaded to 6,000 lb. per square inch without failure. At one end the lock walls will pass through this rock into a hard conglomerate of cemented sand and gravel which requires blasting before it can be removed.

In order to settle beyond question the suitability of the material for foundations, the President recently appointed three eminent engineers to report on the matter. They have visited the Isthmus, examined carefully all the samples from test holes, examined the material as uncovered in the test pits, and their verdict has been that the material is entirely suitable. This opinion corroborates the opinion of the members of the Board of Consulting Engineers of 1905, who proposed the location of the locks and dams at Gatun, the opinion of the late chief engineer, Mr. Stevens, and the most positive opinion of the engineers in charge of the work on the Isthmus, and all sincerely hope that it may become an accepted fact that there is a suitable foundation for the Gatun locks and dam.

To pass from the 85-ft. level to the Pacific terminus there will be a duplicate lock of 30 ft. lift at Pedro Miguel, with duplicate locks of two lifts at La Boca. These locks will have the same usable dimensions as at Gatun. At La Boca there will also be two earthen dams, which, though important, will contain no unusual features. Locks and dams of the dimensions or at the locations now proposed by the United States, were never contemplated by the French, and no preliminary work had been done towards their construction or even their plans. July first, last, when the type of canal was finally determined, Gatun was a small native village with absolutely nothing to indicate that any construction work was even in contemplation. Since then over 50 houses have been built, a town established with sewers, water works and streets.

Excavation for the lock itself was started about October 1, 1906, and up to April 1, 1907, about 250,000 yards had been removed, of which 100,150 yards were taken out in March with three and one-half shovels, or an average of 1,137 yards per shovel per day. It cost for excavation and disposition a little less than 17 cents per yard. About 225 acres have been cleared on the site of the dam. The preparation of plans of these immense structures, the planning and procuring of an adequate plant for handling the materials of construction, is a large part of the undertaking, and this is now well under way.

Building Construction.—One of the most important features of the work done up to date is that of the construction of buildings. One of the greatest causes for complaint during the early days arose from our inability to properly and comfortably house our men. On account of the popular demand to "make the dirt fly" more men were sent to the Isthmus during the first year than we could properly care for.

The purchase from the French Company included some 1,600 dwellings in a bad state of repair, and nearly all of them unfit for occupancy. These old houses were repaired and new ones built as rapidly as possible. The following statement shows the amount of building done from July 1, 1905, to March 31, 1907:

Old French buildings repaired, many practically rebuilt, 1,074.

New buildings built as follows: 3 commissaries, 15 hotels, 1 church, 8 jails, 2 club houses, 3 post offices, 2 coal chutes, 35 hospital buildings, 21 bath houses, 8 fire department buildings, 1 school house, 67 white bachelor quarters, 6 office buildings, 18 shop buildings, 187 white family quarters, 11 white laborers' quarters, 138 colored laborers' quarters, 28 store houses, 79 cook sheds, 61 closets, 36 laborers' kitchens, 40 miscellaneous buildings, a total of 770 new buildings completed. In addition there are now under construction 249 new buildings and 175 old French buildings under repair. Thirty-five buildings have been moved to new locations.

In this construction there has been used 32,903,000 ft. B.M. lumber, 1,514,500 lb. white lead, 49,300 gal. linseed oil, 37,664 gal. turpentine, 23,600 bbls. cement, 926,772 brick, 51,348 pieces sash, doors and blinds, of which 18,300 pieces were manufactured on the Isthmus; 263,475 square yards of wire cloth screening, 228,000 sheets corrugated iron roofing, 4,226 squares tile roofing, 7,247 plumbing fixtures have been installed, requiring 125,688 fittings; 332,112 ft. of pipe, 91,200 lb. lead, 20,100 lb. solder, 12,800 lb. oakum.

It is said that the plumbing work on the Isthmus will stand a critical comparison with any plumbing work in the world. This is a feature entirely unknown before the advent of the Americans.

At present about 2,000,000 ft. of lumber per month is being used on building construction with other items in proportion. As many as 4,250 men have been employed on this work and the pay roll has reached over $257,000 per month. While the work in this department is not actually canal construction it is as necessary for construction as the building of steam shovels.

Mechanical Deuartment.—Under this department is included the construction, care and maintenance of all rolling stock, engines, cars, steam shovels, etc., and all other machinery except floating equipment used in the construction of the canal and the operation of the Panama Railroad.

As stated before, under the administration of Mr. Wallace, a large amount of modern shop machinery, locomotives, cars, steam shovels, etc., had been ordered and the receipt of this machinery has to a large extent made possible the accomplishment of the results attained during the last twenty-one months.

In July, 1905, the Mechanical Division had in service a working force of 296 American mechanics and 920 colored mechanics and laborers. April 1, 1907, there was in this division a working force of 785 white mechanics and 1,387 colored mechanics and laborers, making a total of 2,172 men.

In July, 1905, there was in service seven modern steam shovels—five 70 ton, two 95 ton—served by 58 old French locomotives that were overhauled and put in serviceable condition, and 727 old French 6-meter dump cars. There were ordered and received 200 50-ton steel flat cars for this service, but the requirements of the Panama Railroad were such in hauling lumber and other supplies for the Commission that we were compelled to turn them all over into that service.

On the 1st of April, 1907, there was in service the following modern machinery, rolling stock, transportation, and excavating appliances:

Three 45-ton steam shovels, 1¾-yd. dippers; 28 70-ton steam shovels, 2½ and 3-yd. dippers; 32 95-ton steam shovels, 5-yd. dippers; 24 19x26-in. cylinder double-ender locomotievs to replace the small and inadequate equipment on the Panama Railroad; 140 19x24-in. modern Mogul locomotives, about 70 tons weight, for use in the excavation work; 20 20x26-in. Mogul locomotives, heavier and with a larger wheel, for long-distance hauling of trains of excavated material; 356 of the old French dump cars were continued in service; 25 miscellaneous dump cars of various patterns to determine whether suitable for our service; 300 Western Wheeled Scraper all-steel dump cars, 12-yd. capacity; 500 all-steel flat cars, 50-tons capacity; 1,470 40-ton capacity wooden flats, specially constructed with one gondola side 3 ft. high, with floor extended 18 in. on other side for handling excavated material; 4 Lidgerwood unloaders, 25-ton pull capacity; 11 Lidgerwood unloaders, 60-ton pull capacity; 22 specially constructed unloading plows, all steel; 13 all-steel earth or bank spreaders; 100 Rodger Ballast Hart Convertible cars, with 2 plow cars for handling crushed rock and gravel for ballasting track and for handling coal; 1 100-ton wrecking crane; 2 75-ton wrecking cranes; 5 20-ton locomotive cranes; 5 10-ton locomotive cranes; 1 steel pile-driver; 6 modern passenger coaches; 12 4-wheeled cabooses.

In addition, there was built at our shops, principally of old French material left on the Isthmus, a number of other appliances for facilitating the work, such as track-shifters, pile-drivers, construction cars, labor-transport cars, etc.

In addition there is on order and undelivered 7 45-ton steam shovels, 15 95-ton steam shovels, 4 25-ton wrecking cranes, 1 10-ton electric crane, 2 20-ton electric cranes, 2 all-steel pile-drivers, 300 large Western Wheeled Scraper all-steel dump cars, 20-yd. capacity; 330 40-ton capacity wooden flats with one gondola side, specially constructed for handling excavated material; 15 Lidgerwood unloaders of 60-ton pull capacity, 14 unloading plows, 10 all-steel earth or bank spreaders of special construction to meet our requirements.

It will be understood that all locomotives, cars, excavating machinery, and in fact, nearly everything we are receiving, comes to us in a "knocked down" condition, boxed up, requiring considerable shop facilities and labor to handle their assembling with any degree of rapidity.

The Cristobal locomotive shops have been completed, consisting of office building, machine shop, blacksmith and boiler shop, erecting shop, 9-pit capacity, served by 50-ft. transfer table; planing mill, power house, large car shop, large storehouse, round-house, 20 stalls, coal-chute, 20 pockets, turntable, and paint shop.

After the completion of these shops, at a cost of about $275,000, the old repair shops of the Panama Railroad were abandoned on account of being inadequate for the purpose and located on ground that could be better utilized for other purposes, and the Cristobal shops were leased to the Panama Railroad on Nov. 15, 1906, these shops being of sufficient capacity to serve the Panama Railroad and the purposes of the Isthmian Canal Commission at that end of the line.

Shops at Gorgona have been built and extended and consist of office building, machine shop, blacksmith shop, boiler shop, erecting shop, 22 pits, served by 50-ft. transfer table; foundry, with a capacity of about 300 tons of iron and 15 tons of brass per month; pattern shop, car shop, planing mill, pattern storage building, paint shop, power house, and other small buildings in the shape of latrines, iron racks, storage sheds, etc.

In order to obtain level ground enough for the location of these shops, it was necessary for us to do approximately 225,000 cu. yd. of excavating and filling. These shops are now in shape to do any work that may develop in the maintenance of all types and classes of machinery with the exception of making steel castings and malleables.

Shops at Empire have been designed and the buildings are now well under way, and it is expected that they will be in full operation within the next three or four months. The shops are to be especially arranged for the maintenance and repairs to steam shovels, and consist of an office building, machine shop, blacksmith shop, boiler shop, erecting shop, 12-pit capacity, served by 60-ft. transfer table; car shop, planing mill and storehouse. When completed, these shops will approximate an outlay of about $400,000.

A combined locomotive and steam shovel repair shop for the lighter repairs is being built at Paraiso, to cover repairs of machinery at that end of the Culebra Cut. These buildings consist of an office, machine shop, blacksmith shop, boiler shop, erecting shop, 6-pit capacity; storehouse, latrines, iron racks, and storage sheds.

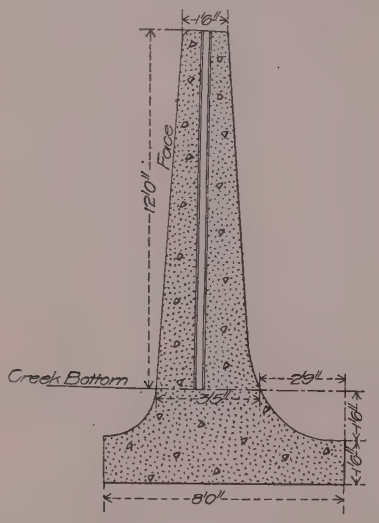
Two-thirds of the machinery in these shops is or will be of the latest modern development, purchased in the United States; the other third, consisting of a better class of the French machinery that was found upon the Isthmus, much of which had never been used.

There has also been established at Las Cascadas a complete plant for storing engines at night and furnishing them light repairs, consisting of a rectangular 5-track engine house, of 40-engine capacity, 20-pocket coal chute, double track cinder pit of modern design, and small repair shop, equipped as usual with round-house division points on railroads in the United States.

A similar plant is under construction at Pedro Miguel, and arrangements have been made for a similar one at Tabernilla.

We have installed and put in operation an electric lighting plant at Empire, which is intended to cover the lighting from Las Cascadas to Pedro Miguel, but is now lighting Empire, Culebra, and Rio Grande. The generating capacity at present is two 100 kw. outfits in full operation, and we are now installing one 200 kw and furnishing about 4,000 lights.

At Gorgona we are installing one 100 kw. with another 100 kw. soon to arrive, this plant being arranged to light the city of Gorgona, about 2,000 lights.



Detail of Flood Wall.

There are about ten miles of 3-phase No. 4 wire pole lines in operation, all buildings now being erected and nearly all already erected at Ancon, Culebra, Empire, Gorgona, and Cristobal being wired for electric lighting.

At Cristobal an electric fire alarm system has been established with numerous stations, protecting the buildings, offices, shops, docks and storehouses as far as Mt. Hope and the Panama Railroad buildings.

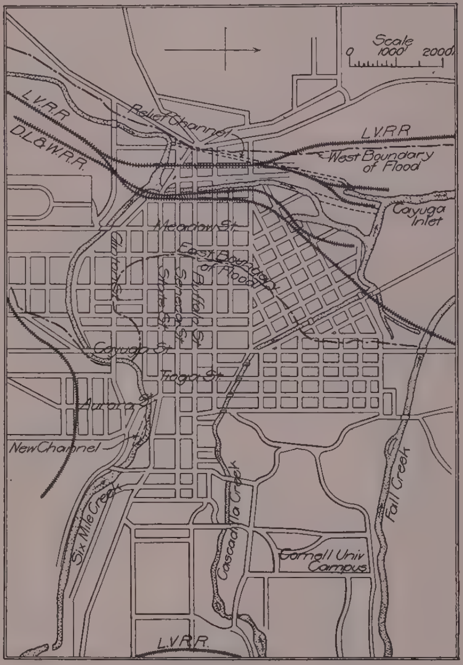
There has also been established and fully equipped at Gorgona, an instrument repair shop for handling the repairs to levels, transits, current meters, fluviographs, clocks, watches and instruments of precision.

There has also been established a 10-in. air pipe-line of extra heavy pipe, extending from Pedro Miguel to Bas Obispo, about nine and one-half miles, just outside of the edge of the Canal prism, with 6-in. and 4-in. leads into the canal prism,—all drills and rock crushers in service now being operated by air. To avoid any local trouble, instead of one central air compressing plant being established, three plants have been located—one at Rio Grande, one at Empire, and one at Las Cascadas—each plant being designed to furnish 10,000 cu. ft. of free air per minute at 100 lbs. pressure, and feeding into one main.

(To be continued.)

Flood Protection at Ithaca, N. Y.

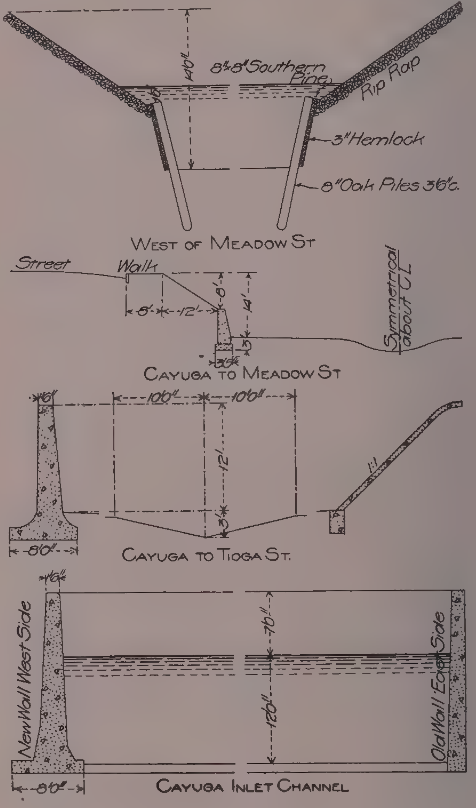
The city of Ithaca has a population of about 18,300 inhabitants and its corporate limits enclose a 14,100 x 9,462-ft. rectangle at the head of Cayuga Lake. About a square mile of marsh from 1 to 3 ft. above the nominal lake level occupies nearly the full width of the valley between the end of the lake and the inhabited portion of the city and is covered by Cayuga Inlet, a crooked channel with a maximum depth of about 6 ft. and an average width of 100 ft. The general direction of the inlet is south from the end of the lake to the area included in the accompanying map. The surface of the ground rises gradually from an elevation of about 7 ft. above the lake in the vicinity of the inlet to about 32 ft. at the intersection of State and Aurora Sts., about 1¾ miles from the lake. East of this point the ground slopes upward with streets graded from 12 to 15 per cent. until a height of about 500 ft. above the lake level is attained in the city limits, the Cornell campus being at a height of about 450 ft. All of the business district and about one-half of the residential part of the city lies west of Aurora St. and the remainder is principally located on East Hill surrounding Cornell University. The hills on the east and west sides of the valley are about 1 mile apart at their bases and the land between them is approximately level. A third hill commences just south of Six Mile Creek and with the east and west hills encloses three sides of the area shown on the map.



Map of Lower Portion of Ithaca.

An area of about 300 square miles adjacent to Ithaca is drained by Fall Creek, which has an outlet into the Lake south of the territory shown in the map, and by Cayuga Inlet. The latter has a drainage area of about 100 square miles and tributary to it are Cascadilla Creek with a drainage area of about 40 square miles and Six Mile Creek draining about 50 square miles. The creeks enter the town through deep rocky gorges which in some places are very narrow and in others have high falls and cascades. The creeks are subject to sudden freshets from melting snow and storms, and their floods, especially when combined, have caused great damage to property in the lower part of the city. The basin of Six Mile Creek is especially subject to sudden storms that, nothwithstanding its smaller area, have made it the cause of much more damage than the other creeks in all of the great floods since 1857. More or less damage occurs nearly every year from the overflow of one or more of the creeks, and in 1903 and 1905, the damage from this cause reached about $200,000. During a storm in June, 1905, the estimated flow was 12,000 cu. ft. per second for Six Mile Creek and 6,000 cu. ft. per second for the Inlet south of State St. Both streams overflowed their banks north of their junction and inundated about 1 square mile of the city, as indicated on the map by the broken line.

The banks of Six Mile Creek were protected in some places by piles and sheeting, as shown in the accompanying photograph looking upstream from Clinton St. During this flood the water was 3 ft. deep over the top of the dyke and had a calculated velocity of 16 ft. per second, which washed away a two-story frame dwelling house and blacksmith shop, located on the left bank in the foreground of the picture and carried it against an iron truss bridge at Clinton St., which it destroyed and buried under 4 ft. of debris 200 ft. farther downstream. At the same time a new steel bridge across Six Mile Creek at Meadow St. was also carried away, together with a large quantity of lumber. This lumber together with other floating debris from Six Mile Creek and from the Inlet banked up against the pile trestles and piers of a trussed swing bridge across the Inlet at State St., which considerably obstructed the channel and formed a dam sufficient to raise the level of the water 3 ft. Similar bridges cross the Inlet at Buffalo and Seneca Sts. and offer considerable obstruction, but being built over State waterways are not under the control of the local authorities.



Wall for Six-Mile Creek and Inlet.

In 1894 an exhaustive study of the flood problem was made by Messrs. Rudolph Hering and James H. Fuertes, in connection with an investigation of the sewerage and drainage of the city. In order to relieve the Inlet channel from the excessive storm flow below its junction with Six Mile Creek, they recommended the construction of a parallel relief channel, indicated on the map by dotted lines, about three-quarters of a mile long, running along the foot of West Hill, north from a point near the foot of Cherry St., to a large inlet channel below the mouth of Cascadilla Creek. They also advised dyking all the streams and draining of all the lowlands after floods with pumps. Records kept by Prof. C. L. Crandall show that the lake level is subject to fluctuations of about 4½ ft. above normal and that at the maximum height an ordinary storm will cause the inundation of 2½ square miles of city area. Some relief is expected from a proposed change in the alignment of the State Barge Canal.

The Legislature of 1906 passed an act creating the Creeks, Drainage and Park Commission of Ithaca, which at once authorized the preparation of plans and the award of a contract for works to confine Six Mile Creek to a safe channel. This involves an estimated cost of about $102,000 and includes the modification of the channel and the construction of side walls and slopes for about 7,000 ft. from a point about 400 ft. east of State St. bridge upstream to a point about 1,500 ft. east of Aurora St.

From Meadow St. to the lower end of the improvement the bottom will be excavated from 4 to 6 ft., and a channel 67 ft. 2 in. wide at the bottom will be enclosed between rows of inclined 8-in. oak piles 3½ ft. apart on centers, driven to a penetration of 6 ft. below the new bottom. They will be sheeted on the back with horizontal 3-in. hemlock planks, with an 8x8-in. pine cap, from which the surface of the ground will rise at a slope of ½ to 1 to a height of 14 ft. above the bottom of the channel. The slope will have an 18-in. rip-rap protection.

Up Stream from Clinton St., Showing Present Protection.

From Meadow St. to Cayuga St. where the creek runs between attractive residential streets the ordinary flow will be confined between vertical reinforced concrete walls 75 ft. apart and 6 ft. above the bottom of the channel. They will have extended footings carried down 3 ft. below the bed of the creek and backfilled to protect them from undermining or scour. From the tops of the walls there will be 1 to 1½ sodded slopes to a total height of 14 ft. above the creek bed. On one side of the creek trees will be planted, while on the opposite side large trees already growing there will be retained. Beyond this slope there will be, on each side of the creek, an 8-ft. sidewalk, a street and a second sidewalk, the width of the street and the outer sidewalk varying somewhat on the opposite sides of the creek.

From Cayuga St. to Tioga St. there will be, for dry weather flow, a central channel 20 ft. wide and 3 ft. deep, with the bottom gently sloping up from its edges for a width of 20 ft. on each side, and on the convex side of the channel there will be a reinforced concrete wall with a footing 8 ft. wide, 3 ft. below the bed of the creek. On the opposite side there will be either a 6-ft. vertical wall, an upper slope like that between Cayuga St. and Meadow St., or there will be, as shown in the cross-section, a small depressed concrete wall at the toe of a 1:1 slope 12 ft. high faced with 4½ in. of reinforced concrete. Above Aurora St. the channel will be rectified, as indicated by a dotted line on the map, and will be protected on the concave side by a reinforced concrete wall and on the convex side by an inclined concrete facing, as shown for the section between Cayuga St. and Tioga St. The wall is reinforced by ½-in. round vertical steel bars 12 in. apart on centers 2 in. from the back, with their lower ends curved and extended to the toe of the footing. This wall is being built in sections 50 ft. long, each containing about 83 cu. yd. of concrete, and the adjacent sections are connected by vertical expansion joints. To make the joints tapered wooden cores 5 in. wide on the face and 5 in. deep are placed in both ends of each form and after the concrete is set and the two adjacent sections of walls are completed the cores are withdrawn and the spaces left by them are filled with concrete, forming keys which bond the successive sections entirely together. The concrete is made 1:3:4 with Cayuga Lake Portland cement and broken stone or gravel passing a 2-in. ring and refused by a ¼-in. screen. Small bolders not exceeding 8 in. in diameter may be bedded in the concrete. After the forms are removed the face is painted with cement wash applied with a brush and immediately covered with ½ in. of 1:2 plaster applied with a wooden trowel and painted with medium-thick cement wash.

The foundations for the concrete slope facing are dressed and compacted, and covered with a layer of sand or gravel, on which the slabs 8 ft. wide are cast with expansion joints at every third slab. They are made 1:2½:4, with gravel screened through a 1½-in. mesh. Where the slopes are rip-rapped they are covered to a depth of 13 in. with large hand-laid cobblestones having 75 per cent. of the interstices filled with small stones. In some places there is a cut-off of 4-in. tongue and groove sheet piling driven to a depth of 3 ft. below the creek bottom. Near Clinton St. there is a concrete runway on the south side of the creek and on Tioga St. concrete underpinnings are required for three adjacent buildings.

A stone retaining wall on the west side of the creek west of Aurora St. will be repaired by a concrete face 6 in. thick on top 18 in. thick at the bottom and extending 3 ft. below the bed of the creek.

The concrete is mixed medium wet in a Ransome mixer and has been successfully laid when the temperature was 20°. In freezing weather the concrete water was heated to about 120° by steam from the mixer boiler, and although the sand and gravel were sometimes frozen when put in the mixer the concrete was discharged from it at a temperature of 60° to 70°. The resulting wall was satisfactory except in one case, where a portion at the top was frozen through carelessness. The forms are made from 1-in. dressed matched siding, laid horizontally with truly vertical butt-joints. They are braced externally, and the inner face is covered with soft soap to prevent the adhesion of the concrete. The forms are made in panels 9 ft. and 6 ft. long; five panels of 9 ft. and one of 6 ft. make a section of wall 50 ft. long from the face of the wall and the same number for the back. These panels are joined together by ½-in. bolts and when set up the face and back are held together by 1-in. bolts.

The principal quantities required for the flood prevention works include 7,760 ft. of reinforced concrete vertical walls 9 and 15 ft. high, 725 ft. of reinforced concrete slope walls, 1,950 ft. of pile and timber docking, 200 ft. of rip-rap wall, 91,000 cu. yd. of earth excavation, 1,200 cu. yd. of rock excavation, and minor items. The contract was awarded to the McGrevey Construction Co., of Ithaca.

The excavation from Cayuga St. East is done by two steam dredges placed in the stream. The excavated material is placed by them in dump wagons and taken away. That part of the stream west of Cayuga St. will be excavated by a dredge worked from a platform placed on two plate girders. These girders will span the entire width of the stream after the concrete walls are built, and will be moved forward on tracks laid on the walls. The material will be removed in dump wagons and will amount to about 65,000 cu. yd. All excavation for foundation of concrete walls is done by manual labor.

At the smallest cross-section of the inlet, about 50 ft. north of State St., the width is only 62 ft. and at normal height its area is not sufficient for the flow of Six Mile Creek and the Inlet in times of large floods. Plans have, therefore, been prepared to enlarge this section to a capacity of 18,000 cu. ft. per second and to deepen, widen, and straighten the Inlet from State St. to the Lake, a distance of about 1¾ miles. The new width will be 100 ft. from State St. north to a distance of about 3,000 ft., beyond which it will be increased to receive the additional flow from Cascadilla Creek. New steel bridges will be built at State, Seneca and Buffalo Sts. to replace the existing structures. When these improvements are completed it is believed they will provide for the safe flow from a storm equal to the greatest on record, that of June 21, 1905, and in connection with the proposed Barge Canal improvements will do much to revive the shipping business along Cayuga Lake. As the Lake and the Inlet up to State St. are State waters the matter has been referred to the State engineer and it is now before the Legislature. It is stated that unless it becomes a law and these improvements are made, the waters of Six Mile Creek, confined between high embankments will, if delivered to the present inadequate channel of the inlet, be twice as great as can be cared for and may do great damage to the property adjacent to the creek and the Inlet. The plans have been made and the work is being constructed under the direction of Mr. Edward Hayes, M. Am. Soc. C.E., engineer of the Creek, Drainage and Park Commission.

Cement for Building Construction.

Report of the Committee on Cement for Building Construction of the National Fire Protection Association.

Ever since this committee was appointed it has been investigating the general subject of cement and concrete as used in various types of building construction, with a view to determining their value as a fire resistive material, and endeavoring to formulate a standard specification for their use which should be both safe and commercially practicable. This has been no easy task since the real nature of cement itself and its action under varying conditions when combined with other materials have been so little known, and have been the subject of such wide difference of opinion between various authorities, and, furthermore, there has been so very little experience in actual fire with buildings of any sort of concrete construction. However, the past few years have marked rapid progress in the concrete building art, and while it is still far from perfection, and high authorities still differ on some technical points, they are getting nearer together on the fundamental features, and we believe are sufficiently agreed on such points as pertain directly to fire resistance to warrant the recommendation, in rather general terms, of a specification for reinforced concrete building construction.

The National Board of Fire Underwriters, through its Committee on Building Construction, has recently issued a revised edition of a model building code, and is urging its adoption by municipalities throughout the country. Section 110 of this code, referring to reinforced concrete construction, has been somewhat revised and is submitted herewith as being as practical and acceptable a specification as the present state of the art will permit. It is, of course, expected that in time experience will necessitate modification or amplification of this standard, but your committee is unable to see any probability of sufficiently important developments in the near future to warrant further delay in the promulgation of such rules as experience has already proven wise.

There are three general features of this specification which we feel warrant especial emphasis; features which experiences of the past year or two particularly have amply proved as being those always likely to need the most careful consideration on the part of all concerned.

Design of Reinforcement.—While this is a point on which there is more difference of opinion between engineers than any other, the specifications here outlined have been drawn by eminent authorities, and we believe will produce a building safe from all points of view, and will meet with as nearly universal approval as any specification which might be devised at present, and at the same time are sufficiently broad to accommodate the special features of many so-called "systems."

We would also call attention to a point omitted in the specification, namely: that the design of such buildings should be undertaken only by engineers of special training and experience along this line. Some of the alluring advertisements of patented systems of reinforcement may seem to indicate that the erection of a building using some particular design is easy, and does not require much experience, etc., but the fact is there are many intricate questions which cannot be solved by the aid of advertising text-books or stereotyped specifications, and we would urge that the design of a building of this type should only be entrusted to trained engineers of recognized ability in this particular direction, just as would be the case if a steel frame building or bridge of equal importance was under consideration.

Insulation of Steel Reinforcement.—In our report of 1905 this matter was discussed at some length, and the result of tests given, which we still believe indicate the necessity of better insulation than the one inch thickness which present practice generally provides. We have no further comment to make on the basis of experimental tests, but practical experience since that time, particularly in the San Francisco fire, has amply demonstrated the need of heavier insulation.

There were thirty-one buildings involved in this great conflagration having more or less concrete construction. In most of them the concrete was used only for floor panels between steel beams, and was made, in some cases, of cinders, but chiefly of stone. After the fire some of these floors were found in fairly good condition; that is, in cases where steel columns and girders supporting them had been sufficiently insulated from heat to stand up. In most cases, however, the protection on columns and girders was so thin, or frail, or of such poor material, that the steel members either collapsed or buckled so badly as to ruin many of the floor slabs. There were no buildings involved having reinforced concrete columns, but there were several which contained beams and girders of reinforced concrete, and from these we may draw valuable lessons on this question of the insulation of steel.

The Young or Seller Building, corner Market and Spear Sts., was a five-story structure with brick walls and steel frame with intermediate floor beams of concrete, having a most primitive type of reinforcement, which though probably not in favor anywhere at the present time, serves as an extreme illustration of the point under discussion. These beams were in effect reinforcing webs projecting from the lower face of the floor slabs and consisted of a flat rolled steel strap about 5 in. wide by ⅜ in. thick, with each end hooked over the upper flange of steel girders and bowed downward so that its center hung about 8 in. below the lower face of the slab. On the top of this suspender strap was formed the concrete beam or web. There being no protection for the bottom or edges of the steel strap, of course, it was quickly heated up to a point where it failed to carry its load, and the floor either collapsed or was badly deformed, the amount of damage depending upon the amount of heat in different localities. The Hall of Justice was of practically the same construction and suffered the same damage to a somewhat less degree, owing to the protection of suspended metal lath and plaster ceilings. Construction of this type is probably a thing of the past, and would not be recognized as worthy of the term reinforced concrete. It is cited here, however, to illustrate the point that steel reinforcement needs adequate insulation.

The Johnson Building, corner of Minna and First Sts., is a five-story brick-walled structure, occupied for harness and leather goods store. In this case the columns and main girders were of steel, but there were numerous intermediate floorbeams of so-called reinforced concrete, although the reinforcement in this particular case seems to have been hardly worthy of the name. Instead of a well-selected type of steel bars made for the purpose, it seems that a miscellaneous collection of old, twisted wire and various-size rods were used, which, even if in good condition, were not heavy enough to carry their loads with safety, and, furthermore, were located not over one inch from the bottom face of the beams. The contents of this building undoubtedly produced a hot fire, though not at all abnormal for a mercantile house, and the result was the collapse of a portion of the building, and such a serious cracking and bending of most of the beams and floors as to render them valueless for further use. Bad design and improper insulation both contributed to the serious failure in this case.

Pacific States Telephone & Telegraph Company's main office building, on Bush St. A brick-walled steel frame building, with flat gravel concrete floor slabs between beams. In the roof construction were a number of small-size intermediate beams of reinforced concrete, having their steel members imbedded apparently about one inch from the lower surface. The upper stories of the building were filled with supplies of various kinds, and the heat was naturally severe in these upper stories, including the one immediately under the roof. These concrete beams were badly deflected, one of them failing entirely. In this case the steel columns throughout the building were insulated by 3 in. of stone concrete, and, to the best of our knowledge, were not themselves injured, although the concrete covering was naturally weakened for some distance from the surface and will doubtless have to be replaced.

Careful Workmanship.—The necessity for improvement along this line has long been recognized, and here, at least, there is little possibility of disagreement as to what is needed.

The experiences of this past year have given additional proof of the gross carelessness and incompetence which have prevailed in many important works. There have been several instances of the collapse of large and expensive buildings in course of construction which have in every case been traced to neglect of well-known rules of safety. For instance, in one case the direct superintendence of the work was left to cheap help, who did not appreciate the necessity for accurate and careful workmanship, and the result was too little cement, too little water, or improper mixing, which allowed the collapse of the building wall before it was half up. In several cases the concrete has been allowed to freeze while under construction, and, naturally, it fell down on removal of forms.

The wooden molds or forms have not been properly cleaned out before receiving the concrete, with the result that shavings, blocks of wood and other refuse have been embedded in concrete in such a way as to make a vital weakness at important points in the building. Certain steel reinforcing rods, called for by plans, have been either misplaced or omitted entirely, which together with unsafe design of original plans, caused one very serious collapse. Concrete foundations have been laid in mud, with the natural result that they failed to support the superstructures. Blocks of wood, for the purpose of holding fixtures, have been found purposely cast in the bottom of beams in such a way as to directly expose the steel reinforcement when the said block was burned or knocked out.

While calling attention to the unusual number of such failures occurring in the last year, it is only fair to admit that the number of buildings erected is also very much greater than in any previous year, and the proportion of failures may not be so much larger. Moreover, it is very encouraging to notice the extensive discussion which these failures have provoked in engineering journals, and the widespread condemnation by the public in general of the methods which have allowed these accidents, all of which must naturally tend to prevent, in some measure, the repetition of the errors in future by making it a commercial necessity for concrete builders to regulate this personal element which is especially prominent in concrete work in order to insure a sufficient degree of public confidence to secure permanence of their industry.

The section of the Building Code submitted refers especially to structures of reinforced concrete throughout, but the rules are also generally applicable to concrete floors and roofs between steel beams and girders as far as they relate to preparation and handling of the concrete itself. In such steel framed buildings concrete may safely be used for floor and roof slabs and for insulation of steel work, provided it is of the specified quality, is securely attached to the steel member by steel rods, expanded metal or woven wire and is thick enough to protect against penetration of heat, which thickness in the opinion of this committee should be not less than 4 in. on all columns, 2 in. around and under all ordinary beams and girders, and 4 in. on the sides of large, heavily loaded girders in mercantile or storage buildings.

These rules are intended to provide for buildings of any ordinary occupancy, including mercantile or manufacturing houses or buildings subject to conflagration exposures, and we believe such structures built in strict conformity with these specifications, though not fire-proof to the last degree, will be found sufficiently fire-resistive to merit the term fire-proof as generally used. This, however, is far from suggesting that concrete buildings as now being constructed are to be so regarded. The general practice at present, as already pointed out, involves too much carelessness in workmanship and too little insulation of steel work, defects which may not appear as vital under slight or moderate fire tests, but which in many cases would surely so appear, if the building were to be subjected to a long-continued hot fire, as from the burning of a stock of merchandise, or the severe attack of a conflagration.

Hollow Concrete Blocks.—The past year has witnessed a wide increase in the production of these blocks for various purposes, but no important changes in method of manufacture or use.

The formulation of a standard for the manufacture and erection of these blocks has had the careful attention of this committee, but such action has thus far been deferred in the hope that field experience and laboratory tests would develop a general line of practice which might be found both safe and practical, and we still believe that before a final conclusion can be reached as to just what materials, what shapes and sizes and methods of manufacture produce the most fire-resistive blocks, it will be necessary to await further laboratory tests, particularly those under way at St. Louis. For the present we have to report that this year's investigations of the subject have tended to strongly confirm our previously expressed view that well-made blocks are suitable for small buildings, where no high temperatures or long-continued fires are to be expected, but that the hollow form in which they are made absolutely precludes their being classed as highly fire-resistive, or suitable for fire walls, or for any buildings which may be subjected to severe fire.

The extensive series of tests under the auspices of the Government at the St. Louis laboratories and our Chicago laboratories jointly are not completed, and we do not feel justified in making any extensive report on progress. However, we are at liberty to say that in the fire tests thus far made, as well as similar tests conducted for the city of Washington, D. C., practically all of the samples have been broken or cracked from unequal expansion of the various sides.

This committee also made a similar test about two years ago, which has not heretofore been reported, for the reason that we did not feel justified in drawing conclusions from a single trial of blocks of one type; the result, however, was concurrent with those of the other tests referred to.

The reason for such breaking is perfectly clear; concrete has almost exactly the same coefficient of expansion as steel; that is, it will expand at the rate of about .000006 of its length per degree of temperature, so that if one side of a hollow block be subjected to a severe fire long enough to heat it to several times the temperature of the other side (the connecting webs or sides being absolutely rigid and non-elastic) there must be a break between two sides. Of course, the thicker the wall or shell of a block is, the longer time will be required to heat it to the breaking point; hence, the thicker the shell, or in other words, the nearer the block comes to being solid the less likely it is to break under fire.

This objection of breaking by unequal expansion applies particularly to the simple, hollow, box-like block which is the one by far most commonly used at present, though it also doubtless applies in large measure to the so-called two-piece blocks, whether the inner and outer pieces be tied together by metal bonds or by irregular projecting wings of the block itself. In such cases the expansion of the inner side or wall would doubtless tend to break the bond between the two and seriously weaken the wall.

One of the most recent forms of concrete block is a small solid block the size and shape of an ordinary clay brick and to be used in the same way. From the standpoint of fire resistance the only objection to be offered against such blocks is that the cement, like that in any concrete, whether in block or monolithic form, will dehydrate in time on the application of high temperatures, and they are, therefore, less fire-proof than good, well-burned clay brick, though it would seem that for most ordinary small buildings such small blocks may be rated as equal to common brick for walls of the same thickness.

The larger solid blocks of so-called artificial stone made of finely ground stone and cement, which are used largely for decorative purposes, would doubtless compare favorably with natural stone, and as is the case with stone, any carved or uneven surfaces would doubtless suffer similarly from heat.

While we are not prepared to submit a detailed standard for the manufacture and use of hollow blocks, and even doubt the necessity for attempting to regulate very closely the manufacture of a type of building material which can only be recommended for low credit in fire resistance, the fact must be recognized that the material is being very extensively used and commercial necessity demands that it be given some definite grade as compared wtih other building materials. We therefore beg to state our opinion that a hollow concrete block wall is better than a frame wall for the simple reason that it is incombustible and will withstand moderate fires which would feed upon and destroy wood, but it is inferior to a brick wall on account of liability to breaking from unequal expansion, probability of continuous cracks through wall at imperfect mortar joints and especially on account of present tendency to poor workmanship in manufacture.

The regulation of this personal element of workmanship can only come about in the course of years of experience and the recognition and control of it from our point of view will have to be left to the individual judgment of various authorities having local jurisdiction. In other respects, the highest fire resistance will be found in the block that has

1st. The thickest shell, or being nearest solid (should never be less than 2 in. thick).

2nd. That contains a good brand of Portland cement tested and found to conform to the standards of the American Society of Civil Engineers or similar specification.

3d. That contains one part cement to not more than four parts sand or other aggregate.

4th. Is made with the wettest mixture practicable.

5th. Is most carefully cured or aged not less than thirty days before using, during which it is frequently moistened by water spray or steam.

6th. Which provides solid blocks for the course on which joists or girders rest instead of allowing said timbers to rest on or hang to the inner side of a hollow shell which may break off.

APPENDIX—*Section 110 of Building Code Recommended by National Board of Fire Underwriters.*—The term "reinforced concrete" or "concrete-steel" in this section shall be understood to mean an approved concrete mixture reinforced by steel of any shape, so combined that the steel will take up the tensional stresses and assist in the resistance to shear.

Reinforced concrete construction may be accepted for fire-proof buildings, if designed as hereinafter prescribed; provided, that the aggregate for such concrete shall be hard-burned broken bricks, or terra-cotta, clean furnace clinkers, entirely free of combustible matter, clean broken stone, or furnace slag, or clean gravel, together with clean siliceous sand, if sand is required to produce a close and dense mixture; and provided, further, that the minimum thickness of concrete surrounding and reinforcing members one-quarter inch or less in diameter shall be one inch; and for members heavier than one-quarter inch the minimum thickness of protecting concrete shall be four diameters, taking that diameter, in the event of bars of other than circular cross-section, which lies in the direction in which the thickness of the concrete is measured; but no protecting concrete need be more than four inches thick for bars of any size; and provided, further, that all columns and girders of reinforced concrete shall have at least one inch of material on all exposed surfaces over and above that required for structural purposes; and all beams and floor slabs shall have at least three-quarters inch of such surplus material for fire-resisting purposes; but this shall not be constructed as increasing the total thickness of protecting concrete as herein specified.

All the requirements herein specified for protection of steel and for fire-resisting purposes shall apply to reinforced concrete filling between rolled-steel beams, as well as to reinforced concrete beams and to entire structures in reinforced concrete. Any concrete structure or the floor filling in same reinforced or otherwise, which may be erected on a permanent centering of sheet metal, of metal lathing and curved bars or a metal centering of any other form, must be strong enough to carry its loads without assistance from the centering, unless the concrete is so applied as to protect the centering as herein specified for metal reinforcement.

Exposed metal centering or exposed metal of any kind will not be considered a factor in the strength of any part of any concrete structure, and a plaster finish applied over the metal shall not be deemed sufficient protection.

All concrete for reinforced concrete construction whenever used in such buildings must be mixed in a machine which mixes one complete batch at a time, and entirely discharges it before another is introduced. At least twenty-five complete revolutions must be made at such a rate as to turn the concrete over at least once in each revolution for each bath.

Before permission to erect any concrete-steel structure is issued, complete drawings and specifications shall be filed with the Commissioner of Buildings, showing all details of the construction, the size and position of all reinforcing rods, stirrups, etc., and giving the composition of the concrete.

The execution of work shall be performed by workmen under the direct supervision of a competent foreman or superintendent.

All forms and centering for concrete shall be built plumb and in a substantial manner with inside surfaces smooth and made tight so that no part of the concrete mixture shall leak out through joints, cracks or holes, and after completion shall be thoroughly cleaned out, removing shavings, chips, pieces of wood and other material, which should not be permitted in forms.

The reinforcing steel shall be accurately located in the forms and secured against displacement while the concrete is being placed and tamped.

Concrete shall be placed in forms as soon as practicable after mixing, and in all cases immediately after the addition of water.

Whenever fresh concrete joins concrete that is set, or partially set, the surface of the old concrete shall be roughened, cleaned and thoroughly slushed with a grout of neat cement and water.

Concrete shall not be installed in freezing weather; such weather shall be taken to mean a temperature of thirty-two degrees Fahrenheit, or lower; concrete shall not be allowed to freeze after being put in place, and, if frozen, shall be removed.

The time at which forms and centering may safely be removed will vary from twenty-four hours to sixty days, depending upon temperature and other atmospheric conditions of the weather; the time for such removal to be determined by the Commissioner of Buildings.

The concrete shall be mixed in the proportions of one of cement, two of sand and four of other aggregates as before provided; or the proportions may be such that the resistance of the concrete to brushing shall not be less than 2,000 pounds per square inch after hardening for twenty-eight days, but for reinforced or plain concrete columns the mixture shall not be leaner than one part of cement, two of sand and five of the coarser aggregate in any case. The tests to determine this value must be made under the direction of the Commissioner of Buildings. The concrete used in concrete-steel construction must be what is usually known as a "wet" mixture.

Only high-grade Portland cements shall be permitted in reinforced concrete-steel constructed buildings. Such cements, when tested neat, shall, after one day in air, develop a tensile strength of at least 300 pounds per square inch; and after one day in air and six days in water shall develop a tensile strength of at least 500 pounds per square inch; and after one day in air and twenty-seven days in water shall develop a tensile strength of at least 600 pounds per square inch. Other tests, as to fineness, constancy or volume, etc., made in accordance with the standard method prescribed by the American Society of Civil Engineers, may, from time to time, be prescribed by the Commissioner of Buildings.

The sand to be used must be clean, sharp grit sand, free from loam or dirt, and shall not be finer than the standard sample kept in the Department of Buildings.

The stone used in the concrete shall be a clean, broken stone, of a size that will pass through a three-quarter-inch ring, or good gravel may be used in the same proportion as broken stone, or broken hard bricks, or terra-cotta, or furnace slag, or hard, clean cluinkers may be used.

The steel shall meet the requirements of Section 21 of this Code. [Section 21—Steel.—All structural steel shall have an ultimate tensile strength of from 54,000 to 64,000 pounds per square inch. Its elastic limit shall be not less than 32,000 pounds per square inch and test specimens, ruptured in tension, must show a minimum elongation of not less than 20 per cent. in eight inches. Rivet steel shall have an ultimate strength of from 50,000 to 58,000 pounds per square inch.]

Concrete-steel shall be designed in accordance with the following assumptions and requirements:

(1) The adhesion between the concrete and the steel is sufficient to make the two materials act together; the unit value of the adhesion is at least equal to the unit shearing strength of concrete.

(2) The design shall be based on the assumption of a load four times as great as the total working load (ordinary dead load plus ordinary live loads) producing a stress in the steel equal to the elastic limit, and a stress in the concrete equal to two thousand pounds per square inch.

(3) The modulus of elasticity of concrete at two thousand pounds per square inch is equal to one-eighteenth of the modulus of elasticity of steel.

(4) The steel takes all the tensile stress.

(5) The stress strain curve of concrete in compression, when the stress in the extreme fibre is two thousand pounds per square inch, may be assumed:

(*a*) As a straight line.

(*b*) As a parabola with its axis vertical and its vertex on the neutral axis of the beam, girder or slab, or

(*c*) As an empirical curve with an area one-quarter greater than if it were a straight line, and with its center of gravity at the same height as that of the parabolic area assumed in (*b*).

(6) The assumption belonging to the common theory of flexure, where not modified by any of the foregoing, will apply.

In the design of structures involving reinforced concrete girders and beams, as well as slabs, the girders and beams shall be treated as T-beams, with a portion of the slab acting as flange, in each case. The portion of the slab so acting shall be determined by assuming that in any horizontal plane section of the flange, the stresses are distributed as the ordinates of a parabola, with its vertex in the stress strain curve and with its axis in a longitudinal vertical plane through the center of the rib of the T.

The shearing strength of concrete, corresponding to a compressive strength of two thousand pounds per square inch, shall be assumed at two hundred pounds per square inch.

All reinforced concrete T-beams must be reinforced against the shearing stress along the plane of junction of the rib and the flange. Where reinforced concrete girders carry reinforced concrete beams, the portion of the floor slab acting as flange to the girder must be reinforced with bars near the top, at right angles to the girder, to enable it to transmit local loads directly to the girder and not through the beams, thus avoiding an integration of compressive stresses due to simultaneous action as floor slab and girder flange.

Concrete in direct compression shall not be stressed, under the working load, more than three hundred and fifty pounds per square inch. Reinforced compression members shall be designed on the assumption that this stress in the concrete will be simultaneous with one of six thousand pounds per square inch in the steel. Should the use of hooped concrete be proposed the working stresses will be a subject of special consideration by the Commissioner of Buildings.

In the execution of work in the field work must be so carried on that the ribs of all girders and beams shall be monolithic with the floor slab.

In all reinforced concrete structures special care must be taken with the design of joints to provide against local stresses and secondary stresses due to the continuity of the structure.

In the determination of the bending moments due to the external forces, beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor plates, when constructed continuous and when provided with reinforcement at top of plate over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than $0.1\,WL$; the bending moment may be taken at $0.05\,WL$ in the case of square floor plates which are reinforced in both directions and supported on all sides.

When the shearing stresses developed in any part of a reinforced concrete or concrete-steel constructed building exceed under the multiplied loads the shearing strength as fixed in this section, a sufficient amount of steel shall be introduced in such a position that the deficiency in the resistance to shear is overcome.

When the safe limit of adhesion between the concrete and steel is exceeded, provision must be made for transmitting the strength of the steel to the concrete.

Concrete-steel may be used for columns in which the ratio of length to least side or diameter does not exceed twelve. The reinforcing rods must be tied together at intervals of not more than the least side or diameter of the column.

The contractor must be prepared to make load tests on any portion of a reinforced concrete or concrete-steel constructed building within a reasonable time after erection as often as may be required by the Commissioner of Buildings. The tests must show that the construction will sustain a load with a factor of safety for floors and structural members as required by Section 136 of this Code.

[Section 136—Factors of Safety.—Where the unit stress for any material is not prescribed in this Code the relation of allowable unit stress to ultimate strength shall be: (*a*) As one to four for metals, subjected to tension or transverse stress; (*b*) as one to six for timber; (*c*) and as one to ten for natural or artificial stones and brick or stone masonry. But wherever working stresses are prescribed in this Code, varying the factors of safety herein above given, the said working stresses shall be used.]

Canal Zone Sanitation.

Canal zone sanitation is the subject of an interesting article in the "Medical Record," by Colonel Gorgas ,who is responsible for the sanitary system on the Isthmus. The most interesting part of his article relates to the prevention of malaria. This is still the main cause of sickness on the Isthmus; during March, for instance, the people sick with malaria numbered somewhat less than 20 per 1,000, and the sickness from all causes was about 23 per 1,000. Colonel Gorgas considers that this is as small a rate as would probably have occurred had the work been done in the United States, and he does not expect that it will be possible to lower it. He considers that the following results may fairly be claimed for the sanitary work on the Isthmus under his direction: When the United States authorities took control of the Isthmus in 1904 the territory along the route of the canal was in its normal condition as to health. It was overgrown by a dense tropical jungle; the natural conditions were everywhere ideal for breeding stegomyia and anopheles mosquitoes. The region was inhabited by a considerable population, which was very poor as a result of the failure of the French Canal Co., and the recent bloody and destructive war which had involved the whole country for about three years. Malaria, dysentery and smallpox were prevailing among the people about as they would anywhere in the tropics under similar conditions. Yellow fever infection was present in both Panama and Colon. The conditions were more favorable for producing a high mortality upon the introduction of a large force than they had been at any time in the past. Into this region the canal commission has introduced the largest force ever present on the Isthmus, some 40,000 people, of whom one-quarter are white non-immunes. Nevertheless the sanitary measures during the period of the introduction of this unprecedented force have been such that yellow fever has disappeared, malaria has been held in check and the total sick rate was reduced to 23 per 1,000, as stated above.

The Belmont Tunnel, New York.

The Belmont tunnel under the East River at Forty-second St., New York, connects the Boroughs of Queens and Manhattan and is intended to convey passenger traffic from Long Island City to the vicinity of the Grand Central Depot, New York. It has two parallel single-track tunnels 28 ft. apart on centers and about 17,000 ft. in total length, counting from Park Ave. to the temporary terminus about 3,000 ft. from the shore line in Long Island City. From both these points the grade descends toward the center of the river, where it attains a maximum depth of about 110 ft. below high water. The tunnel cross-section is of three types, a horseshoe shaped concrete lining 12½ ft. wide and 13½ ft. high inside for rock excavation; a circular cast-iron lined section with a clear inside diameter of 15½ ft and an over-all diameter of 16 ft. 10 in. in the subaqueous portion built by the shield methods; and on Long Island, about 1,800 ft. of double-track rectangular cross-section with reinforced concrete lining.

Inner Face of Shield.

Outer Face after Service.

Preliminary surveys were made in 1904 and the first shaft was commenced in July, 1905; since then sinking, excavation and construction have been carried on rapidly and continuously. The preliminary soundings indicated rock and hardpan overlaid by sand to a depth of 5 to 30 ft., and a minimum roof of about 23 ft. above the tunnel. The greatest depth of water was about 60 ft. and the maximum current about 5 miles per hour. Shaft No. 1 is near Third Ave., Manhattan; Shaft No. 2 is near the shore of the East River, Manhattan; Shaft No. 3 is on the reef in the middle of the river, and Shaft No. 4 is on the Long Island shore. Power houses were established and air compressor plants installed in them on the surface of the ground at Shafts 2, 3 and 4, as described in The Engineering Record of March 3, 1906. The tunnel work has all been executed in pairs of headings driven in both directions from the foot of each shaft, sixteen headings in all, all of which are substantially completed, excepting the four under the channel of the river, where excavation by the shield method is still in progress. The headings from shafts Nos. 1, 2, 3 and 4 were commenced in solid rock under atmospheric pressure and were carried on without pneumatic pressure by the top heading and single bench method except in the headings driven from Shafts 2 and 4 toward the river, and from Shaft 3, which passed from rock into gravel and sand excavated by the shield method. Before these excavations emerged from the rock, they were enlarged to form chambers in which the shields were assembled on concrete inverts and from which they were afterwards advanced to make the subaqueous excavation.

Shaft No. 3 was sunk through a cofferdam built on the top of the reef in the middle of the tunnel and was commenced in open excavation which had to be discontinued when it was found impossible to exclude the water from the excavation. Two vertical steel cylinders 11 ft. in diameter were provided with air locks and were sunk under pneumatic pressure to the required depth of 98 ft., where lock chambers were excavated and the shields were assembled and started in both directions from its foot. The shields were received in pieces small enough to pass through the air locks and the cylindrical outer shells were first assembled on rollers with horizontal longitudinal axles which supported the heavy steel plates and enabled them to be revolved around the axis of the tunnel. When half of the cylinder had been assembled, the diaphragm and girders were assembled to it and the whole structure was revolved part way in either direction while more plates and beams were added to it until finally the entire shield was assembled and thoroughly riveted, the heavy pieces being all handled by tackles suspended from eye-bolts drilled into the solid rock in the roof of the erection chamber.

In each of the river headings a group of air locks were placed near the foot of the shaft. The material lock, 6 ft. in diameter, with a capacity of three dump cars, was located at track level about 3 ft. above the invert. Alongside this was placed a pipe lock about 3 ft. above track level, and over them the emergency lock 3 ft. in diameter and 16 ft. long, accessible by a stairway and landing platform over the material lock. After these locks were located in their proper position, the space around them up to the lining of the rock wall was filled solid with strong concrete which served as a bulkhead resisting the air pressure. After the heading had advanced more than 300 ft. beyond them safety diaphragms were built into the lining if required to provide refuges for the men in the headings and insure access to the locks.

The machinery installed for the power plants at the respective shafts is as enumerated in the previous article, except that at Shaft 3 two 500-h.-p. boilers were installed to operate two air compressors of a combined capacity of 1,500 cu. ft. per min. The limited area included between the walls of the crib cofferdam surmounting the reef did not afford space for the installation of more boilers and it was, therefore, necessary to run the remaining three air compressors by electric motors. The combined mechanical installations of all the shafts is now rated at about 5,000 h.-p.

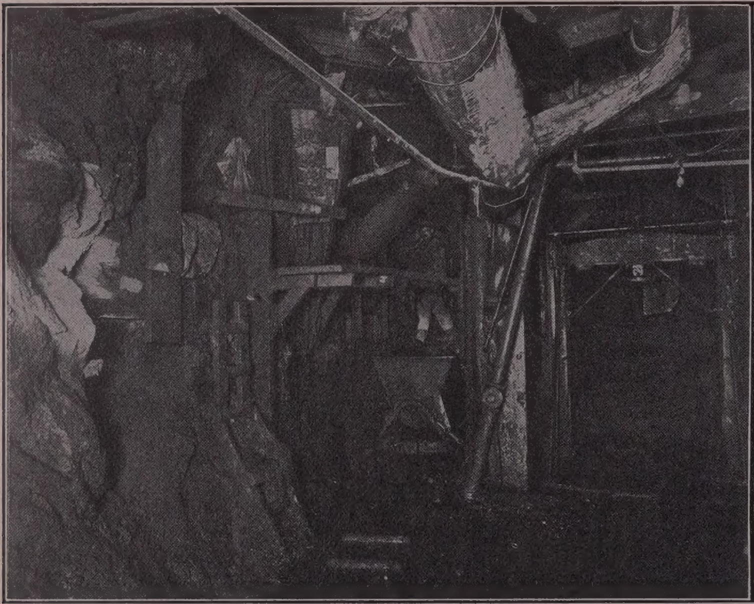
Concrete materials are delivered at Shaft 1 through chutes as required to small storage bins at the foot of the shaft, whence they are drawn through gates in the hopper bottoms to the Ransome concrete mixer, which delivers to dump cars in the bottom of the shaft. Concreting has not yet been commenced at Shaft 3, but at Shaft 4 the concrete is mixed in a Ransome machine on the surface of the ground and delivered to the tunnel in dump cars.

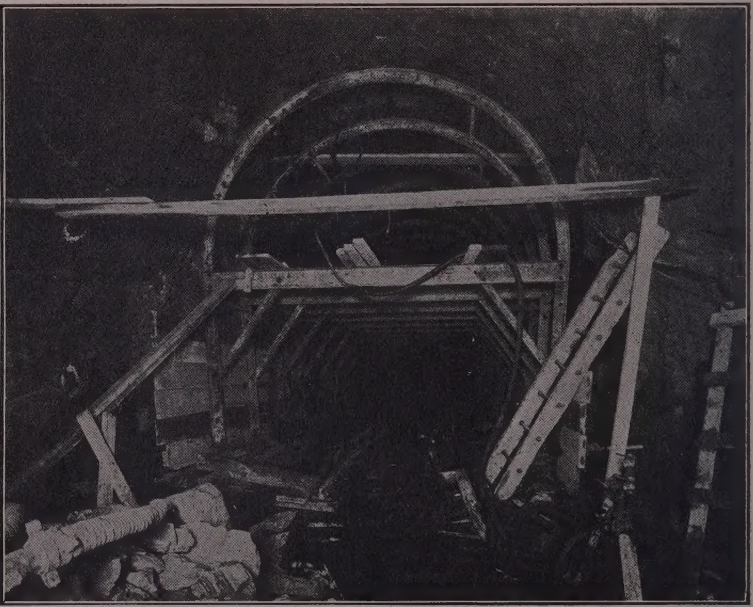
Where the headings are run on a down grade, as is now the case with those from the Long Island shaft, the inclination of the tunnel is such that air in it will collect at the shore end and it has not been considered necessary to provide safety diaphragms or special appliances to give refuge in case of an inrush of water. On the other hand, where the headings are being driven on an up grade as is now the case with those from the Manhattan end, diaphragms about 8 ft. deep bolted between the flanges of the tunnel segments are provided in the roof and moved forward from time to time so as to keep within a maximum distance of 200 ft. from the heading. On the forward side of the diaphragm stairs are provided reaching to their lower edge and connecting there with an elevated platform extending to the emergency air lock, above the material lock, thus providing refuge and certain escape for men in case the tunnel should fill.

So long as the shields continue moving constantly less trouble is developed in bad ground, but as soon as it is necessary to stop the shield in bad ground, the air escaping from it is forced upward through the loose soil and very rapidly disintegrates it so that the swift tidal current washes it away and often creates large holes over the shield. Sometimes these holes have become so large that the upper part of the shield has been actually exposed to the clear water, and the roof has consequently disappeared. It has been found possible to advance the tunnel somewhat even under such conditions as these where the lower part of the shield encountered large gravel and boulders without any earth or sometimes encountered rocks which required blasting before it could be advanced.

Whenever it was possible under such conditions quantities of clay were dumped in the river above to form a blanket or temporary roof over the tunnel. Part of this clay has been received from

Haverstraw and from points where excavation or dredging is carried on in the vicinity. Besides which the muck excavated from the shield is saved and is used for the same purpose. Many thousands of yards of material have thus been dumped over the tunnel. In order to make this roof blanket efficient it is necessary that the air pressure in the tunnel should be reduced so that not very much boiling of the water occurs while the clay is being deposited, otherwise the ebullition drives the descending clay away and leaves the tunnel shield bare notwithstanding the efforts to cover it. During a part of the winter it was found impossible to get clay from the usual supply and the work was carried on, as already said, as well as possible without its use. Of course under such conditions the leakage from the shields and through the tunnel roof was excessive.


Concrete Plant and Elevator in Shaft.


Steel Centering for Concrete Lining.

After the completion of the headings worked from Shaft No. 2 the compressors there were diverted to the use of Shaft No. 3 and the compressed air was carried to it in a main running through the tunnel to supplement the supply from the compressors on the reef. The working pressure now averages about 33 to 35 lb. in the different headings and the men work two three-hour shifts with alternate three-hour intervals of rest. Every precaution is taken to insure the health of the men and to safeguard them. They are required to come out of the locks at a rate of one minute for every three pounds pressure, and are required to remain sometime in the dressing room, where abundance of hot coffee is served to them and every effort is made to prevent them from indulging in any dissipation which, however, cannot be entirely prevented.

The shields and the hydraulic erectors handling the tunnel segments are similar to those used in the Battery tunnel, already described in these columns. The hydraulic jacks which operate the shields are worked by a maximum pressure of 6,000 lb. per sq. in. developed in the power house and transmitted down the shaft and through the tunnel to the shield.

In some cases the shields have been advanced through the sand without excavating in front where the material was very soft, the movement, however, soon compacted the material so densely that the shield was stopped and the material excavated through the openings in the steel diaphragm. Where the sand is very soft the slope under the hood of the shield is excavated as rapidly as possible and the face is supported by a bulkhead of horizontal boards braced back against the diaphragm of the shield and is often filled in with hay to prevent the fine sand from penetrating through the cracks. The pneumatic pressure is maintaned about equal to the hydrostatic pressure at the centre line of the tube; it is in excess of the hydrostatic pressure in the upper part of the shield where less difficulty is experienced in keeping out the water while excavation is in progress. On the contrary in the lower part of the shield the hydrostatic pressure is greater than the pneumatic pressure and the tendency is very strong for the water to enter through the lower doors when they are opened for excavating the earth or gravel beyond them. In bad ground the doors are, of course, kept closed except during the time that excavation is actually being made through them.

To prevent distortion of the lining from temporary unbalanced pressures every alternate ring is provided as soon as set with a horizontal tension member consisting of a 1¼-in. round bar with sleevenut adjustment and pin-connection to bolts put through the flanges of the ring at the springing line. This rod is screwed to a moderate initial tension and entirely prevents flattening of the ring. If the location is in soft ground where grouting is not necessary, the material will settle back around the ring and develop a balanced exterior pressure after which the tension rod may be removed without danger of any distortion to the ring.

The land headings are now completed and the work is being carried on with a 20-man gang in each of the four river headings. Those of the north tube had approached within about 300 ft. of each other and those of the south tube within about 400 ft., when the notes for this article were made March 22. An average progress of about two rings in 24 hours was then made in each heading. The segments, weighing about 1,200 lb. each are planed for bearing on the exterior of their vertical flanges and on the interior have recesses which are filled, after they are assembled, with special threads of lead about ¼ in. diameter, which are thoroughly calked in position and afterwards are backed up with mortar, well calked in up to the inner surface of the flange. The flange bolts are provided with grummets soaked in red lead and covered with steel washers. Before the joints are calked they are covered immediately after assembling with well-kneaded clay, which is plastered over them by hand as rapidly as the work advances and serves to prevent much loss of air until the calkers, who are kept as near the shield as possible, can go over them.

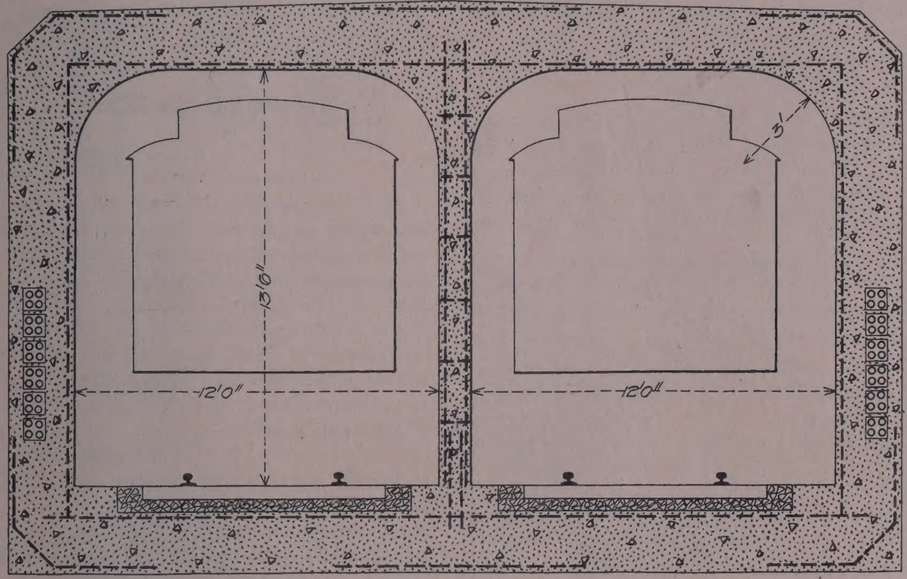
The soil is removed from the heading in one-yard steel end-dump cars running on 20-in. tracks, supported by cross timbers about 3 ft. above the tunnel invert. Where the grade is down toward the shaft, these wagons are run by gravity, but where it is up they are hauled by cables operated by hoisting engines driven by compressed air and located clear of the track on overhead cross timbers bolted to the tunnel segments. The dump cars are hoisted in the shafts and from them are run on overhead tracks to tipples or aprons from which their contents are discharged to dump scows. At the east end the double-track reinforced concrete section has been built in open cut and back-filled and the work now in progress there chiefly consists in repaving and in readjustment of the water, gas and sewer mains. Some of the adjacent segments of the north and south tubes have been removed under the center of the river and an opening has been cut through from one tube to the other and in it a sump has been constructed and is now being concreted to provide for drainage and pumping of the finished tunnel. The total force now employed includes about 1,500 men.

The tunnel was designed and its construction is conducted under the direction of the New York & Long Island Railroad Co., Mr. St. John Clarke, chief engineer, and Mr. Allan Appleton Robbins principal assistant engineer. The work is being executed by the Degnon Contracting Co., Mr. Robert Shailer, chief engineer.

THE MILWAUKEE NORTHERN RY., which has been under construction for some time, is a typical example of the most advanced type of interurban electric railways. It will open up communication between Sheboygan, Port Washington, Fond-du-Lac, West Bend and other towns in Eastern Wisconsin and Milwaukee. This district is extensive, rich and populous, but has been practically isolated from Milwaukee because of inadequate transportation facilities. Except for short distances in the heart of some of the larger cities, the track is located on its own right of way and in almost a straight line. There is only one important curve on the road and that is of 2 deg. The entire absence of grade crossings is a feature which will permit a high-speed schedule to be maintained; these crossings have been eliminated by steel bridges and viaducts, many of them of quite large size. The main power house is at Port Washington and will contain at the outset three alternators of 1,000-kw. capacity direct connected to gas engines, these units being the largest yet employed for traction purposes.

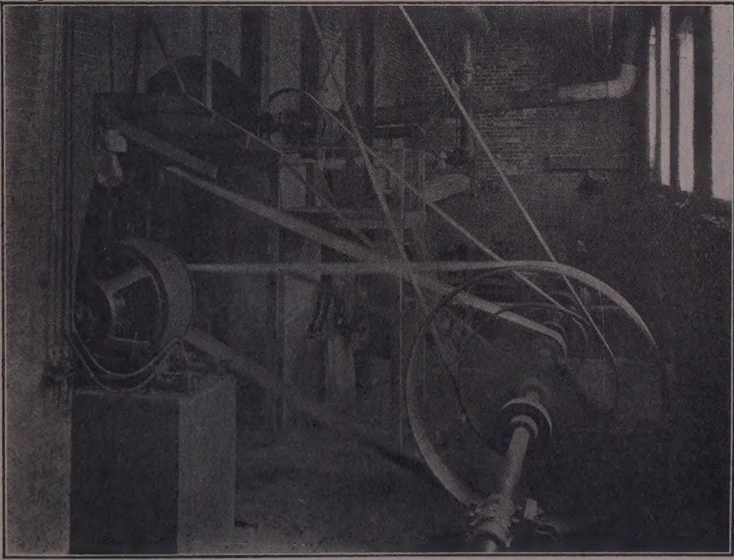
Electrical Equipment of the Grand Rapids Pulp & Paper Co.

The power requirements of pulp and paper mills present many problems arising from conditions peculiar to this class of industries. Continuity of service and uniform speed are essential to the successful manufacture of paper as when a run is started it must be continuous, and any lack of uniformity in speed seriously affects the quality of the product. The starting conditions of some of the machinery are severe and a large overload capacity in the motive power is therefore necessary.

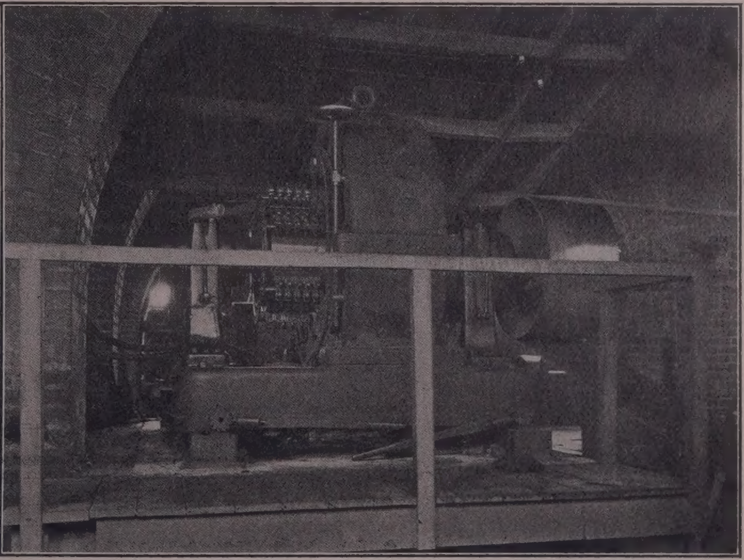


Land Section, Belmont Tunnel.

Electric motors have been adopted to a considerable extent by pulp and paper manufacturers. A flexibility in power transmission is gained which permits the delivery of power directly at the various points of application, and the control of each section or individual machine is placed directly in the hands of the operative. Another feature of paper machinery which makes electric motors useful is that the wire, press rolls, dryers and machine rollers operate at variable speeds. It is essential for the speed variations to cover a considerable range and be easily controlled. In existing direct current plants where it is deemed advisable to install direct current motors, the variable-speed feature is provided by the use of motors whose speed is regulated by field control, and which have a sufficient range to eliminate the use of mechanical speed-changing devices. This simplifies the system and prevents the loss of power in overcoming the friction of belts and moving parts. The variable speed motor is easily controlled and has a definite known speed, for each notch of the controller, which gives the operator an intelligent conception of the speed of his machine at all times.



Constant Speed Drive for Paper Machine.



Variable Speed Motor Driving Paper Machine.

An illustration of such equipment is found in the plant of the Grand Rapids Pulp & Paper Co., at Grand Rapids, Wis. The mills are located on the Wisconsin River about four miles from the town, where an abundance of water power is available. The electrical equipment was laid out by Mr. V. D. Simons, general manager of the company, and installed under his direct supervision. The pulp mill, where the stock is prepared for the manufacture of paper is operated by water power, but the various processes afterward carried on employ electric drive.

One of the essential conditions of paper making is that as the weight or thickness changes the speed of the machine must be easily altered to provide for changes in the rate of production, which is usually accomplished by mechanical means. In the present case, however, the engineer accomplishes this result by the use of variable speed motors.

There are two Beloit paper machines, the smaller of the two having a capacity of 525 ft. per minute, or a total of 21 tons per day, the width of the paper being 84 in. before and 78 in. after trimming. There are 29 dryers and a 70-ft. wire. That portion of the machine which operates at variable speeds is driven by a 100-h.-p. variable-speed shunt-wound motor with a speed variation of 470 to 750 r. p. m., which is obtained by field control. Tests show that the actual power required to drive the variable-speed portion of the machine at 525 ft. per minute is 101 h.-p. That portion of the machine which operates at constant speed is driven by a 50-h.-p. motor.

The larger machine has a capacity of 26 tons of paper per day at the rate of 475 ft. per minute, 104 in. wide before and 97 in. after trimming, and is provided with 25 dryers and a 60-ft. wire. The variable speed portion is driven by a 100 h.-p. shunt-wound motor with a speed variation ranging from 470 to 750 r. p. m., obtained by field control. The actual power determined by tests to drive the variable speed part of the machine is 97 h.-p. The constant speed portion is driven by a 50-h.-p. motor. The use of shunt-wound motors permits the use of field control, which has the advantage of high efficiency and good regulation throughout its range.

In the cutter room there are two cutters and an elevator operated by a 10-h.-p. back-geared motor, which replaced 250 ft. of 3 7-16 in. line shaft. A 10 h.-p. motor driving a fully equipped machine shop for general repair work completes the electrical equipment.

The present daily average output of this company is 45 tons of news paper.

There are four 6x16-ft. return tube boilers equipped with underfeed stokers. The furnaces are the Dutch oven type arranged for burning refuse wood and screening coal. A 54-in. Buffalo Forge Co.'s fan operated by a 10 h.-p. variable-speed motor furnishes forced draft.

The generator equipment consists of a 200-kw., 220-volt, engine-type, direct-current generator direct-connected to a 22x36-in. Corliss engine operating at 125 r. p. m., and a 150-kw. generator of the same characteristic belted through a countershaft to a water-wheel. The rated speed of this generator is 600 r. p. m., and it operates in parallel with the engine-driven machine. An interesting feature in the regulation of the water-wheel is the arrangement for controlling the gates. They are operated by a series-wound reversible back-geared motor, started, stopped and reversed by means of a double push-button on the switchboard. There is also an attachment on the governor of the engine for automatically controlling the motor, thus regulating the respective loads of the two generators. The entire electrical equipment was furnished by the Westinghouse Electric & Mfg. Co., including the switchboard which is of standard Westinghouse construction and consists of two generators and three feeder panels.

Book Notes.

The hydraulic features of water power development are given special attention in a book by Mr. R. C. Beardsley, on the "Design and Construction of Hydro-Electric Plants." Other volumes on the subject recently issued give far more attention to electrical features and for this reason this new volume will doubtless have a welcome from many who have found the lack of details concerning dams, canals, penstocks, water-wheel settings and the like in other books a somewhat serious omission. The first three chapters are devoted to hydraulic principles, methods of measuring the flow of streams and the reconnaissance of water powers. The fourth chapter is a description of the materials employed in power plant developments and the methods of using them. The fifth chapter is a long one explaining in considerable detail the operations followed in building such works; there is also considerable information on the design of some parts of them, notably dams. The author devotes a large amount of space to the reinforced concrete gravity type of dam, which has lately been coming into prominence. The construction of the power house has a chapter to itself, which is followed by one on the equipment of such stations, in which special attention is paid to the water-wheels and their settings. The eighth chapter, on power transmission, relates more to the methods of carrying on construction than it does to the details of electrical design, which are more fully treated in other books. The last chapter is a collection of tables and formulas useful in designing hydro-electric plants. (New York, McGraw Publishing Co., $5.00.)

The third volume of the "Handbuch fuer Eisenbetonbau" is devoted to methods of carrying out construction. The first portion is on foundations and walls and is the work of Dr. F. von Emperger, well known to many American engineers during his visit to this country for the purpose of introducing the Monier system of reinforced concrete. It describes a great variety of foundations for buildings, bridges, retaining walls, pumping wells and other structures. Methods of designing certain features of these works are explained and there is a very complete series of drawings and illustrations of work of this class, particularly that in which reinforced concrete piling has been employed. The second section of the book is by Mr. A. Nowak, of the engineering staff of the Austrian Railways. It is devoted exclusively to the construction of parapets, retaining walls, quays and piers. The third section, by Professor F. W. O. Schulze, of Danzig, is on hydraulic works of various sorts and opens with a description of concrete revetments of canals, rivers and dykes. The construction of numerous breakwaters is described in considerable detail, and there are illustrations of a great number of different harbor works executed in reinforced concrete. Many European landing stages and landing bridges, for example, are now constructed of reinforced concrete throughout and the details of them which are given of considerable interest, in view of the trouble experienced in many parts of the United States in securing timber piles at a reasonable cost. The construction of wiers and dams is explained and some of the details of these works are interesting, such as the methods of draining some of the recent concrete dams constructed in Germany. There is also a section on reinforced concrete lighthouses. The book is a remarkably comprehensive review of the state of the art in the branches it covers, and is so profusely illustrated that even readers who are not thoroughly familiar with the German language will find it useful in ascertaining what has been done in other countries. (Berlin, Wilhelm Ernst & Sohn, 15 marks.)

Professor M. S. Ketchum has prepared a book on "The Design of Walls, Bins and Grain Elevators," which is likely to prove decidedly useful to a designer who has to take up the preparation of plans for such structures for the first time.

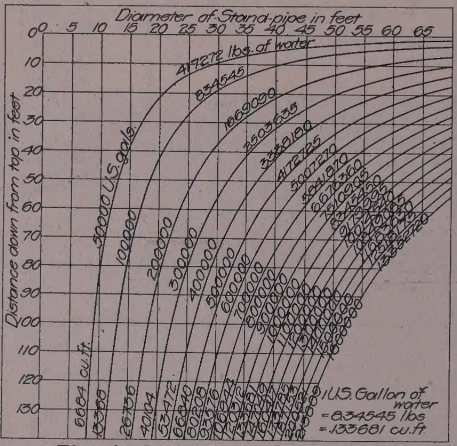


Fig. 1. Capacity of Standpipes.

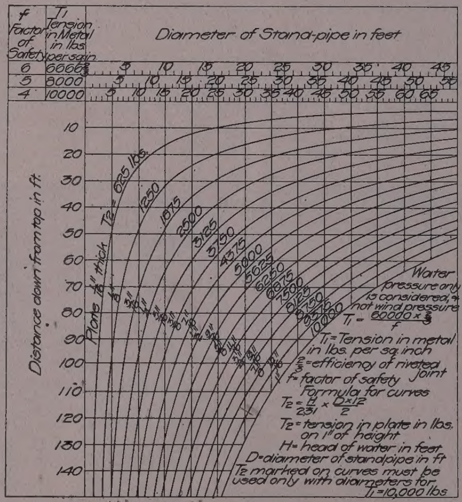


Fig. 2. Plates for Standpipes.

While the preparation of designs for grain elevators is a specialty confined to a few engineers, the design of retaining walls and coal and ash bins is likely to be undertaken in any office. In this book the author has covered not only the theory of such structures, but has given many examples of work of various types, so that the reader has at his command in one book about all the information needed to fit him for undertaking such problems. The theories of earth pressure advanced by Rankine, used in England and America, and by Coulomb, used in Europe, are explained and their application to retaining wall problems is outlined. The author points out, however, that a very large degree of assumption is involved in such theoretical considerations and the teachings of practical experience are very important in all work of this class. The design of bins, as carried on in the offices of engineers who have much of this work to do, is also largely empirical, and accordingly the numerous examples of such work which are illustrated are particularly useful as affording precedents. The section of the work on grain elevators covers a field that is practically untreated elsewhere, except in a few papers before various engineering societies. The book is particularly useful in that the machinery employed in handling materials to and from bins is described at length and some of the features of design which otherwise would be inexplicable are made clear. (New York, Engineering News Publishing Co., $4.00.)

Letters to the Editor.

CALCULATING EARTH VOLUMES.

SIR: In studying the letter from Mr. G. L. Bilderbeck in the last issue of your paper I noted a number of typographical errors that may be confusing and misleading to some of your readers. In formula (8) the expression $\frac{1}{4}\, l\, w\, m$ should evidently be $\frac{1}{4}\, l\, w^2\, m$. The value 2.27 which is used in a number of formulæ should in all cases be 2 × 27, and the value 6.27 in the expression at the head of the last column of the table should be 6 × 27. The values given in the first column "n" of the table should have a decimal point before them in every case, so as to read in hundredths. Though the careful reader would undoubtedly find these typographical errors, it may not be out of place to call attention to them.

Truly yours,
A TRANSITMAN.

New York, June 1, 1907.

WATER-WORKS STANDPIPE DIAGRAMS.

SIR: The two accompanying plates of curves give a quick method of making an approximate design of a water-works standpipe. Several books give tables of data on the thickness of plate and capacity of standpipes, but they occupy much more space than the two plates and one cannot as readily see the effect of changing diameters and factors of safety.

Take for an example a standpipe 25 ft. in diameter and 100 ft. high. From Fig. 1 the capacity is about 370,000 gal., 48,000 cu. ft., or 3,070,000 lb. of water. In Fig. 2, with a factor of safety of 4, the diameters on that line are used. Following the vertical line through the diameter of 25 ft., for the first 9⅔ ft. down from the top the plate is 1/16 in. thick, then 9⅔ ft. of ⅛-in., 9⅔ ft. of 3/16-in., etc. The bottom 3 ft. is 11/16 in. thick. On looking at the other two lines of diameters it is seen that the above thicknesses of plate will be required for a standpipe 20 ft. in diameter with a factor of safety of 5, and 16½ ft. in diameter with a factor of safety of 6. Of course no plate should be used less than ¼ in. thick.

In case one wishes to use a different ultimate strength of metal, efficiency of longitudinal riveted joint or factor of safety from those given in Fig. 2, the method is as follows: With an ultimate strength of 64,000 lb. per square inch in the steel, an efficiency of riveted joint of 50 per cent. and a factor of safety of 8, then

$$I_1 = 64{,}000 \times .50 \div 8 = 4{,}000 \text{ lb.}$$

Now, if the diameter of the tank to be considered is 25 ft., then the thickness of plate under these conditions will be found on the vertical line passing through the diameter of 62.5 ft. with $I_1 = 10{,}000$ for

$$4{,}000 : 10{,}000 :: 25 : d, \text{ or } d = 10{,}000 \times 25 \div 4{,}000 = 62.5.$$

From Fig. 2 the tank would have to be 1 in. thick at the bottom ring if 61 ft. high.

Detroit, Mich. NEAL C. FENKELL.